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Complete List of Authors:	Han, Bing; Shanghai Jiao Tong University, Wang, Ningjian; Shanghai 9th Peoples Hospital Affiliated to Shanghai Jiaotong University School of Medicine Chen, Yi; Shanghai 9th Peoples Hospital Affiliated to Shanghai Jiaotong University School of Medicine Li, Qin; Shanghai 9th Peoples Hospital Affiliated to Shanghai Jiaotong University School of Medicine Zhu, Chunfang ; Shanghai 9th Peoples Hospital Affiliated to Shanghai Jiaotong University School of Medicine Chen, Yingchao Lu, Yingli
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Prevalence of hyperuricemia in the eastern Chinese population

Bing Han*, Ningjian Wang, Yi Chen, Qin Li, Chunfang Zhu, Yingchao Chen and Yingli Lu*

Institute and Department of Endocrinology and Metabolism, Shanghai Ninth People's Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China

Correspondance: Dr Yingli Lu, luyingli2008@126.com and Bing Han, hanbing1423@163.com.

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Statement of authorship

The work has not been published previously, and not under consideration for publication elsewhere. All authors have reviewed and approved the final version.

The author contribution lists

YL, BH designed and supervised this investigation. BH performed this investigation. YC, CFZ and YCC contributed to the data collection. NJW and QL provided technical or material support. All authors read and approved the final manuscript.

Data Sharing Statement

Please contact to corresponding author.

Conflict of interests

The authors have declared that no competing interests exist.

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Compliance with Ethical Standards

All procedures performed in this study were in accordance with the principles of the Helsinki Declaration II.

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Ethical approval

The study protocol was approved by the Institutional Review Board of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine.

Informed consent

Written consent was obtained from all the participants.

Patient and public involvement:

Patients and the public were not involved in this study.

ABSTRACT

Objectives: In the past decade, China has experienced a large scale of urbanization as well as rapid economic growth. The aim of this study was to further investigate the prevalence of hyperuricemia (HUA) in the eastern Chinese population.

Design: Cross-sectional study.

Setting: SPECT-China study.

Participants: In this study, 12,770 residents from 22 sites in eastern China were recruited. Finally, 9,225 subjects were included.

Main outcome measures: The serum levels of uric acid, fasting blood glucose (FBG), HbA1c and other metabolic parameters were tested. The waist circumference (WC), weight, height and blood pressure were also measured. Questionnaires regarding smoking, drinking, education, etc. were collected from the subjects.

Results: The prevalence of HUA in the eastern Chinese population was 12.3% (95%CI 11.6-12.9%) overall, 17.9% (95%CI 16.7-19.1%) in men and 8.5% (95%CI 7.8-9.3%) in women. The incidence of HUA in urban subjects was higher than that in rural subjects (12.9 vs. 10.8, P<0.01). The prevalence of HUA was decreased in men and increased in women. Residents with high BMI levels had a higher prevalence of HUA. In the logistic regression analysis, male sex, urban residency, TC, TG, overweight, obesity, SBP and low economic status were independently correlated with HUA.

Conclusions: The estimated prevalence of HUA in the eastern Chinese population was 12.3% overall and 17.9% and 8.5% in men and women, respectively. HUA has gradually become an important public health issue in China.

Trial registration: ChiCTR-ECS-14005052

Key Words: Prevalence, hyperuricemia, economic growth, public health, risk factors

Article summary

Strengths and limitations of this study

- The estimated prevalence of HUA in the eastern Chinese population was 12.3% overall and 17.9% and 8.5% in men and women, respectively.
- This was a regional survey instead of a national study.
- We did not consider the influence of diet.

Abbreviations: HUA, hyperuricemia; FBG; fasting blood glucose; WC; waist circumference; BMI, body mass index; LDL, low-density lipoprotein; TG, triglyceride; HDL, high-density lipoprotein; TC, total cholesterol.

Introduction

In humans, uric acid is the end product of purine metabolism and is mainly excreted via the kidneys. Xanthine oxidoreductase catalyzes two steps of enzymatic reactions, hypoxanthine to xanthine and xanthine to uric acid. Several conditions could influence the concentration of serum uric acid, including purine-rich food intake, neoplastic disease, cytotoxic drugs, obesity, hypertension, etc [1-3].

Uric acid is reported to be associated with oxidative stress and inflammation [1, 4]. In patients with hyperuricemia (HUA), deposition of uric acid in joints and tissues promotes the occurrence of gout and chronic nephropathy. HUA has also been reported to be associated with insulin resistance, NAFLD [5, 6] metabolic syndrome, type 2 diabetes, atherosclerosis and coronary heart disease [7-11]. The overall prevalence of HUA in adults in the United States was 21.4% in 2007-2008 [12]. However, in Chinese adults, the adjusted prevalence of HUA in 2009-2010 was 8.4% [13].

In the past decade, China has experienced a large scale of urbanization. The percentage of the urban population rose from 18% in 1978 to 56% in 2015 [14]. As serum uric acid is closely related to economic development and urbanization [13], it was necessary to understand the latest prevalence of HUA in China.

China is characterized by regional and economic diversity. Eastern China has a relatively higher economic status than the rest of the country. In the present study, we performed a cross-sectional survey to investigate the prevalence of HUA and its risk factors in the eastern Chinese population.

Methods

Study population

Data of the current study are from SPECT-China, which is a population-based cross-sectional survey on the prevalence of metabolic diseases and risk factors in Eastern China [15]. The registration number is ChiCTR-ECS-14005052 (www.chictr.org). In this study, 12,770 residents from 22 sites in Shanghai, Zhejiang, Jiangsu, Anhui and Jiangxi provinces were enrolled from January 2014 to December 2015. The inclusion and exclusion criteria were described previously. We also excluded residents who had no uric acid data (n=3,535) and CKD5 stage (n=10). Finally, 9,225 subjects were included (Figure 1). This study was approved by the ethics committee of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine. Written consent was obtained from all the participants.

Measurements and definition

HUA was defined as serum uric acid > 420 μmol/L for men and > 360 μmol/L for women [16]. Blood pressure and heart rate was measured by a sphygmomanometer (TERUMO-Elemano) three times. The mean of the three records was used in the analysis. Hypertension was defined as a systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or any self-reported history of hypertension. Diabetes was defined as a self-reported history of diabetes or HbA1c levels of 6.5% or more. Prediabetes was defined as HbA1c concentrations between 5.7% and 6.4%. Normal glucose tolerance (NGT) was defined as an HbA1c less than 5.7% [17]. Weight and height were measured wearing light clothing and without shoes. Body mass index (BMI) was calculated as weight (kg)/height squared (m^2). Overweight was defined as 25 kg/m^2≤BMI<30 kg/m^2. Obesity was defined as BMI≥30 kg/m^2. Waist circumference (WC) was measured at the level of 1 cm above the umbilicus. Demographic information and lifestyle risk factors were gathered from standard questionnaires by trained staff. Current smoking was defined as having smoked at least 100 cigarettes in one's lifetime and currently smoking cigarettes [18]. Current drinking was defined as drinking more than once a month. Current economic status was assessed by the gross domestic product (GDP) per capita of 2013 in each study site. The mean national GDP

per capita (6807 US dollars from World Bank) in 2013 was considered the cutoff point for economic status.

Assessment of biomarkers

Venous blood samples were drawn from all participants after fasting for at least 8 hours and immediately centrifuged (2000 rpm for 15 min) at room temperature. Blood samples were stored at -20ºC when collected and shipped by air in dry ice to one central laboratory certified by the College of American Pathologists within 2-4 hours of collection. All plasma and serum samples were frozen at -80ºC after laboratory testing. Serum UA and other biochemical indexes were analyzed by a Beckman Coulter AU 680 device with the original kit. Insulin was tested by an Abbott i2000 SR analyzer with the original kit. HbA1c was detected using high-performance liquid chromatography (HPLC) by MQ-2000PT (Medconn Technology, Shanghai, China) using commercial reagents (HuaChen Biological Reagent Co., Ltd., Shanghai, China).

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, Version 22 (IBM Corporation, Armonk, New York). Demographic and metabolic characteristics are expressed as the mean ± SD or as the means (95% CI) for continuous variables and percentages (95% CI) for categorical variables in the overall population and in subgroups of location, age, economic status, BMI and glucose status. Logistic analysis was used to investigate the association of demographic, lifestyle, and metabolic factors with the odds of HUA. All analyses were two-sided. $P<0.05$ was considered significant.

Results

Characteristics of the eastern Chinese population

In our study, we analyzed the uric acid in 9,225 Chinese adults, including 3,682 males (age, 55.57 ± 13.23 y) and 5,543 females (age 54.30 ± 12.82 y). Levels of serum uric acid were 352.12 ± 79.30 nmol/L and 269.29 ± 64.68 nmol/L in males and females, respectively. There were significant differences between blood glucose, blood lipids, uric acid, BMI, WC and blood pressure. The incidence of diabetes and hypertension also showed a significant difference (Table 1).

Metabolic risk factors of the eastern Chinese population

The incidence of diabetes and hypertension, WC, SBP and BMI increased with age. As BMI and glucose levels rose, the incidence of hypertension, WC, SBP, BMI, TG, FPG, and HbA1c increased. Moreover, people living in rural areas had a higher incidence of diabetes, WC, SBP, LDL, HDL, TC and HbA1c. People with a high economic status had a higher incidence of diabetes, WC, UA, BMI, LDL, FPG, HbA1c and Cr (Tables 2, 3).

Estimated prevalence of HUA in the eastern Chinese population

The prevalence of HUA was 12.3% (95%CI 11.6, 12.9%), with 17.9% (95%CI 16.7, 19.1%) and 8.5% (95%CI 7.8, 9.3%) in males and females, respectively. The prevalence of HUA in urban areas was higher than that in rural areas (12.9% vs. 10.8%). The ratio of HUA in developed areas was slightly higher than that in underdeveloped areas (12.6% vs. 11.8%). As the BMI increased, the prevalence of HUA increased in both men and women. In women, the proportion of HUA increased in normal, prediabetic and diabetic populations. However, this trend was not obvious in men (Table 4).

Logistic regression analysis of HUA

Male sex, urban residency, increased TC or TG, overweight, obesity, elevated SBP and low economic status were all risk factors for HUA in the eastern Chinese population (Table 5). However, increased age, higher educational status, increased LDL or HDL, current smoking or drinking and elevated DBP were not associated with the risk of HUA.

Discussion

In the Eastern population of China, the prevalence of HUA was 12.3% (95%CI 11.6-12.9%), which was similar to the pooled prevalence of the systematic review in China (13.3%) [19]. However, this prevalence was more than that in the national HUA survey, which reported that the prevalence of HUA was 8.4% [13]. The previous survey in China was performed in 2009-2010. Our study occurred in 2014-2015. These two studies investigated different populations. In addition, our prevalence was relatively lower than that in Qingdao, which is close to the sea and where residents consume high amounts of seafood and beer [20]. Moreover, the incidence of HUA in our population was lower than those in the United States and Japan [12, 21], which might be attributed to economic status.

The prevalence of HUA in young men (<40 years) was six times more than that in young women. However, as the age increased, the prevalence of HUA gradually decreased in men and increased in women, which was coincident with values previously reported [22]. In residents more than 70 years in age, men and women had a similar prevalence of HUA. We deduced that the diet of young men contains more purine than that of old men. The young men also had active metabolisms. The prevalence of HUA was dramatically increased in women older than 50 years, which might be caused by reduced estrogen levels.

In previous studies, the prevalences of HUA in urban areas were much greater than those in rural areas [13, 22]. However, in our study, the prevalence of HUA in urban areas was mildly elevated (12.9% vs. 10.8%). Eastern China was the relatively developed area in the whole country. Therefore, the difference between urban and rural areas was not obvious as in other places.

Risk factors for HUA were also evaluated in our study. We found that male sex, urban residency, hypertriglyceridemia, hypercholesterolemia, overweight, obesity, high SBP and low economic status were risk factors for HUA. In previous studies, hypertriglyceridemia was thought to be the strongest risk factor for HUA [22, 23]. However, the OR for HUA was 1.7 times with 1 SD elevation of triglyceridemia. In addition, obesity was the strongest risk factor (OR=3.035) in our study. China has the largest obese population in the world [24]. In this case, the prevalence of HUA will increase with the rising trend of obesity. Therefore, we should pay more attention to prevent its consequence.

HUA is closely related to lifestyle and dietary habits. In accordance with a previous study, smoking was not associated with HUA [13]. However, according to a previous study, alcohol intake influences the serum UA, which is different from the results of our study. This difference might have been caused by our definition of current drinking (current drinking was defined as drinking in the past 1 month), which mixed non-habitual drinkers and habitual drinkers together.

As the age increased, UA together with components of metabolic syndrome (FPG, SBP, WC) also increased, which indicated there might be a close relationship between metabolic syndrome and HUA. Other studies have also found that HUA is associated with metabolic syndrome [25, 26]. An epidemiologic study showed that HUA is positively correlated to fasting serum insulin [27]. Krishnan et al reported that people with HUA have 1.36 times the risk of developing insulin resistance in a 15-year follow-up study [28]. Thus, research has indicated that insulin resistance plays an important role in the relationship between metabolic syndrome and HUA [29].

There were several limitations in our study. First, this was not a national study but a local survey. Second, we did not consider the influence of diet. Blood was drawn after fasting for eight hours. However, the diet ingested near to the blood drawing time was unknown. In addition, this was a cross-sectional study. Therefore, we could not identify a causal relationship between HUA and its risk factors.

In this study, we estimated the prevalence of HUA in the eastern Chinese population. To prevent the prevalence of HUA, more attention should be paid to life status (such as economic status and residency localization) and metabolic indexes (TC, TG, BMI, and SBP).

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Figure legend

Fig. 1 Flowchart of this study.

We totally collected 12, 770 subjects. After excluding participants who had missing data. Finally, 9, 225 subjects were included

Table 1 Baseline characteristics between different groups.

Variables	Men (n=3682)	Women (n=5543)	P value
Age y	55.57±13.23	54.30±12.82	0.000
FPS mmol/L	5.72±1.63	5.50±1.36	0.000
HbA1c %	5.78±1.08	5.64±0.92	0.000
TG mmol/L	1.88±1.79	1.55±1.20	0.000
TC mmol/L	5.14±1.13	5.27±1.15	0.000
LDL mmol/L	3.23±0.77	3.30±0.83	0.000
HDL mmol/L	1.30±0.31	1.45±0.32	0.000
Uric acid umol/L	352.12±79.30	269.29±64.68	0.000
BMI kg/m^2	25.11±3.45	24.40±3.67	0.000
WC cm	85.85±9.42	78.72±9.90	0.000
SBP mmHg	134.31±20.71	131.12±22.22	0.000
DBP mmHg	82.12±12.90	77.77±12.93	0.000
Diabetes %	16.3%	12.7%	0.000
Hypertension %	53.4%	44.1%	0.000

Fasting plasma glucose: FPG; Alanine aminotransferase: ALT; Triglycerides: TG; Total cholesterol: TC; Body mass index: BMI; Waist circumference: WC; Systolic blood pressure: SBP; Diastolic blood pressure: DBP

Table 2 Characteristics of Eastern Chinese population.

	% (95%CI)				Mean (95%CI)		
	Diabetes	Hypertension	Smoking	Drinking	WC	SBP	BMI
Overall	14.1 (13.4, 14.8)	47.8 (46.8, 48.9)	19.2 (18.3, 20.0)	55.8 (54.8, 56.9)	81.58 (81.37, 81.79)	132.38 (131.93, 132.83)	24.69 (24.62, 24.77)
Location							
Rural	15.8 (14.4, 17.2)	58.7 (56.8, 60.6)	22.9 (21.3, 24.5)	56.6 (54.7, 58.5)	83.14 (82.75, 83.54)	139.74 (138.86, 140.63)	24.71 (24.57, 24.85)
Urban	13.4 (12.6, 14.2)	43.3 (42.1, 44.5)	17.6 (16.7, 18.6)	55.5 (54.3, 56.7)	80.90 (80.65, 81.16)	129.35 (128.85,129.84)	24.67 (24.59, 24.76)
Age groups							
<40	1.6 (0.9, 2.3)	11.1 (9.4, 12.9)	12.9 (11.0, 14.8)	42.0 (39.2, 44.7)	75.22 (74.63, 75.82)	116.83 (115.99, 117.67)	23.38 (23.18, 23.58)
40-50	5.9 (4.8, 7.0)	31.6 (29.4, 33.7)	17.1 (15.3, 18.9)	53.2 (50.9, 55.6)	78.95 (78.48, 79.42)	125.59 (124.71, 126.46)	24.56 (24.41, 24.72)
50-60	15.3 (13.8, 16.7)	49.4 (47.4, 51.4)	23.5 (21.8, 25.2)	56.2 (54.2, 58.2)	82.14 (81.76, 82.52)	132.39 (131.57, 133.21)	25.02 (24.88, 25.15)
60-70	20.3 (18.8, 21.9)	62.3 (60.4, 64.2)	19.5 (17.9, 21.0)	61.5 (59.6, 63.4)	84.00 (83.63, 84.36)	138.84 (138.00, 139.68)	25.06 (24.91, 25.21)
>70	24.4 (21.9, 26.9)	78.5 (76.0, 80.9)	19.1 (16.7, 21.5)	61.6 (58.7, 64.6)	86.02 (85.42, 86.62)	146.05 (144.81, 147.29)	24.73 (24.51, 24.95)
Economic status							
low	12.3 (11.3, 13.3)	47.8 (46.3, 49.4)	21.2 (19.9, 22.5)	46.6 (45.1, 48.2)	81.07 (80.74, 81.39)	134.20 (133.47, 134.93)	24.50 (24.39, 24.61)
high	15.6 (14.6, 16.6)	47.8 (46.4, 49.2)	17.6 (16.5, 18.6)	62.9 (61.6, 64.3)	81.96 (81.68, 82.24)	130.97 (130.42, 131.52)	24.83 (24.73, 24.93)
BMI							
<25	10.5 (9.7, 11.3)	38.0 (36.7, 39.4)	17.3 (16.3, 18.4)	54.1 (52.7, 55.5)	76.16 (75.94, 76.39)	128.30 (127.72, 128.89)	22.28 (22.23, 22.33)
25-29.9	17.7 (16.4, 19.0)	57.9 (56.2, 59.6)	20.7 (19.3, 22.1)	57.9 (56.2, 59.6)	87.24 (86.99, 87.50)	136.79 (136.06, 137.51)	26.98 (26.94, 27.03)
>=30	26.2 (22.6, 29.7)	73.1 (69.6, 76.7)	24.6 (21.1, 28.1)	59.0 (55.0, 62.9)	96.39 (95.64, 97.15)	142.00 (140.43, 143.57)	32.51(32.21, 32.81)
Glucose status							
normal	-	37.0 (35.6, 38.3)	16.2 (15.1, 17.2)	50.6 (49.3, 52.0)	78.95 (78.68, 79.22)	127.98 (127.42, 128.55)	24.08 (23.99, 24.18)

prediabetes	-	57.6 (55.7, 59.5)	23.4 (21.7, 25.0)	63.2 (61.3, 65.1)	83.90 (83.52, 84.27)	136.70 (135.85, 137.54)	25.26 (25.12, 25.40)
diabetes	-	72.7 (70.3, 75.2)	23.0 (20.6, 25.3)	61.3 (58.7, 64.0)	87.60 (87.05, 88.15)	141.93 (140.76, 143.09)	26.00 (25.80, 26.21)

Table 3 Biochemical index of Eastern Chinese population.

	Mean (95%CI)							
	UA	LDL	TG	HDL	TC	FPG	HbA1c	Cr
Overall	301.84 (300.14, 303.53)	3.28 (3.26, 3.29)	1.68 (1.65, 1.71)	1.39 (1.38, 1.39)	5.22 (5.19, 5.24)	5.59 (5.56, 5.62)	5.70 (5.67, 5.72)	77.35 (77.04, 77.65)
Location								
Rural	294.82 (291.72, 297.92)	3.38 (3.35, 3.41)	1.69 (1.63, 1.75)	1.44 (1.43, 1.45)	5.37 (5.33, 5.41)	5.63 (5.57, 5.69)	5.80 (5.76, 5.84)	73.76 (73.22, 74.29)
Urban	305.55 (303.58, 307.53)	3.23 (3.21, 3.25)	1.67 (1.64, 1.71)	1.37 (1.36, 1.37)	5.16 (5.13, 5.18)	5.57 (5.53, 5.60)	5.65 (5.63, 5.67)	78.87 (78.51, 79.24)
Age groups								
<40	294.08 (289.32, 298.85)	2.80 (2.77, 2.84)	1.35 (1.28, 1.42)	1.39 (1.37, 1.40)	4.60 (4.55, 4.65)	4.98 (4.94, 5.02)	5.09 (5.06, 5.12)	75.82 (75.00, 76.63)
40-50	287.23 (283.32, 291.14)	3.10 (3.07, 3.13)	1.68 (1.59, 1.77)	1.40 (1.39, 1.42)	5.02 (4.97, 5.07)	5.33 (5.27, 5.38)	5.40 (5.36, 5.44)	75.05 (74.39, 75.71)
50-60	305.93 (302.74, 309.12)	3.43 (3.39, 3.46)	1.82 (1.76, 1.88)	1.39 (1.37, 1.40)	5.42 (5.37, 5.46)	5.67 (5.60, 5.73)	5.78 (5.74, 5.82)	77.17 (76.58, 77.75)
60-70	306.36 (303.39, 309.32)	3.44 (3.41, 3.47)	1.74 (1.69, 1.79)	1.38 (1.37, 1.39)	5.42 (5.37, 5.46)	5.80 (5.74, 5.86)	5.95 (5.91, 5.99)	77.64 (77.08, 78.20)
>70	318.74 (314.05, 323.43)	3.37 (3.32, 3.42)	1.58 (1.53, 1.63)	1.38 (1.36, 1.40)	5.34 (5.28, 5.40)	6.00 (5.90, 6.10)	6.06 (6.00, 6.12)	82.43 (81.45, 83.40)
Economic status								
low	299.75 (297.15, 302.35)	3.23 (3.20, 3.25)	1.70 (1.65, 1.75)	1.45 (1.44, 1.46)	5.20 (5.17, 5.24)	5.54 (5.49, 5.58)	5.62 (5.59, 5.65)	76.29 (75.82, 76.75)
high	304.44 (302.28, 306.60)	3.31 (3.29, 3.34)	1.66 (1.63, 1.70)	1.34 (1.33, 1.35)	5.23 (5.20, 5.26)	5.62 (5.58, 5.66)	5.75 (5.72, 5.78)	78.20 (77.79, 78.60)
BMI								
<25	284.75 (282.68, 286,82)	3.19 (3.17, 3.21)	1.44 (1.41, 1.47)	1.45 (1.44, 1.46)	5.13 (5.10, 5.16)	5.42 (5.38, 5.45)	5.56 (5.53, 5.58)	76.19 (75.79, 76.58)
25-29.9	321.87 (319.05, 324.69)	3.39 (3.36, 3.42)	1.94 (1.89, 1.99)	1.30 (1.29, 1.31)	5.32 (5.28, 5.36)	5.74 (5.69, 5.79)	5.84 (5.80, 5.87)	78.88 (78.35, 79.42)
>=30	339.36 (332.47, 346.25)	3.44 (3.37, 3.50)	2.33 (2.11, 2.54)	1.27 (1.25, 1.29)	5.40 (5.32, 5.49)	6.12 (5.96, 6.27)	6.12 (6.02, 6.21)	78.32 (77.11, 79.53)
Glucose status								
normal	294.93 (292.74, 297.12)	3.12 (3.10, 3.14)	1.54 (1.51, 1.58)	1.41 (1.40, 1.42)	5.05 (5.02, 5.08)	5.09 (5.07, 5.10)	5.16 (5.15, 5.17)	76.81 (76.41, 77.21)

prediabetes	313.08 (309.95, 316.22)	3.51 (3.48, 3.54)	1.71 (1.66, 1.75)	1.38 (1.37, 1.40)	5.49 (5.44, 5.53)	5.45 (5.42, 5.48)	5.93 (5.92, 5.94)	77.95 (77.38, 78.52)
diabetes	310.93 (306.50, 315.36)	3.42 (3.38, 3.47)	2.18 (2.06, 2.30)	1.29 (1.27, 1.31)	5.38 (5.31, 5.45)	7.89 (7.75, 8.04)	7.38 (7.30, 7.46)	78.22 (77.33, 79.12)

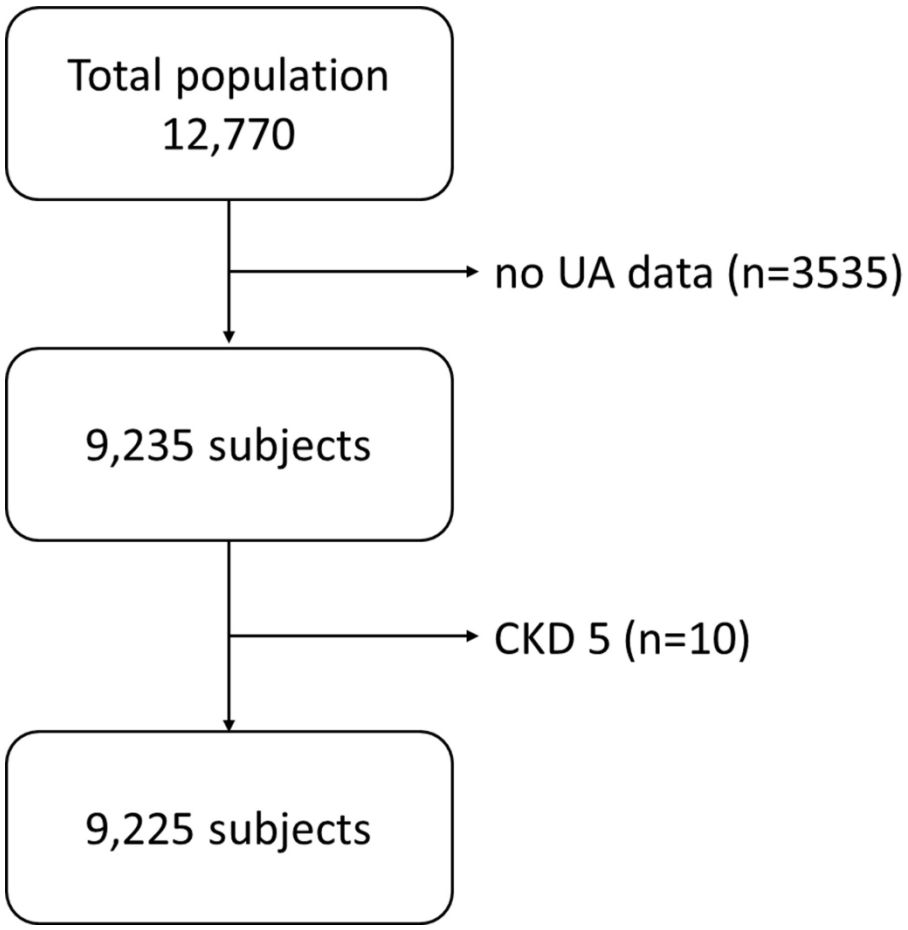
Table 4 Estimated prevalence of HUA in Eastern Chinese population.

	% (95%CI)		
	Overall	Men	Women
Overall	12.3 (11.6, 12.9)	17.9 (16.7-19.1)	8.5 (7.8-9.3)
Location			
Urban	12.9 (12.1, 13.7)	19.1 (17.6-20.7)	8.9 (8.0-9.8)
Rural	10.8 (9.6, 12.0)	15.2 (13.1-17.3)	7.7 (6.4-9.0)
Age groups			
<40	10.8 (9.0-12.5)	22.8 (19.0-26.6)	3.3 (2.0-4.5)
40-50	9.0 (7.6-10.3)	19.3 (16.3-22.3)	3.1 (2.1-4.1)
50-60	12.9 (11.6-14.3)	18.6 (16.1-21.0)	9.2 (7.7-10.6)
60-70	13.1 (11.8-14.4)	15.3 (13.1-17.5)	11.6 (10.0-13.2)
>70	15.9 (13.8-18.0)	15.6 (12.5-18.7)	16.1 (13.2-19.1)
Economic status			
low	11.8 (10.9-12.8)	18.3 (16.5-20.1)	7.2 (6.1-8.2)
high	12.6 (11.7-13.5)	17.5 (15.8-19.2)	9.5 (8.5-10.6)
BMI			
<25	7.8 (7.0-8.5)	12.4 (10.9-13.9)	5.2 (4.5-6.0)
25-29.9	16.4 (15.1-17.7)	22.0 (19.9-24.1)	11.6 (10.1-13.1)
>=30	25.9 (22.4-29.4)	30.2 (24.6-35.8)	22.5 (18.1-27.0)
Glucose status			
normal	10.1 (9.3-10.9)	17.5 (15.8-19.2)	5.7 (4.9-6.5)
prediabetes	15.2 (13.9-16.6)	20.3 (17.9-22.7)	11.6 (10.0-13.2)
diabetes	15.1 (13.1-17.0)	15.0 (12.1-17.8)	15.2 (12.5-17.9)

Table 5 Risk factors for HUA in Eastern Chinese population.

Risk factors	OR	(95%CI)
Female sex	0.502	0.420, 0.599
Age per 10 years	1.039	0.974, 1.109
Urban residency	2.208	1.674, 2.913
≥Junior middle school education	1.050	0.873, 1.263
Lipids		
LDL per 1SD	1.033	0.900, 1.185
HDL per 1SD	0.925	0.840, 1.019
TC per 1SD	1.218	1.043, 1.422
TG per 1SD	1.701	1.517, 1.906
Current smoking	0.941	0.777,1.139
Current drinking	0.916	0.787,1.066
BMI		
Overweight	1.770	1.509, 2.075
Obesity	3.035	2.385, 3.862
Blood pressure		
SBP per 10mmHg	1.059	1.013, 1.108
DBP per 10mmHg	1.011	0.943, 1.084
High economic status	0.693	0.543, 0.886

Data are expressed as unStandardized B (95%CI). The enter procedure was used.



171x157mm (300 x 300 DPI)

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	7
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of hyperuricemia in an eastern Chinese population: a cross-sectional study

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Prevalence of hyperuricemia in an eastern Chinese population: a cross-sectional study

Bing Han*, Ningjian Wang, Yi Chen, Qin Li, Chunfang Zhu, Yingchao Chen and Yingli Lu*

Institute and Department of Endocrinology and Metabolism, Shanghai Ninth People's Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China

Correspondance: Dr Yingli Lu, luyingli2008@126.com and Bing Han, hanbing1423@163.com.

Running title: Prevalence of hyperuricemia in China.

Statement of authorship

The work has not been published previously, and not under consideration for publication elsewhere. All authors have reviewed and approved the final version.

The author contribution lists

YL, BH designed and supervised this investigation. BH performed this investigation. YC, CFZ and YCC contributed to the data collection. NJW and QL provided technical or material support. All authors read and approved the final manuscript.

Data Sharing Statement

Please contact to corresponding author.

Conflict of interests

The authors have declared that no competing interests exist.

Acknowledgments

We thank all the participants in the study.

Compliance with Ethical Standards

All procedures performed in this study were in accordance with the principles of the Helsinki Declaration II.

Funding

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Ethical approval

The study protocol was approved by the Institutional Review Board of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine.

Informed consent

Written consent was obtained from all the participants.

Patient and public involvement:

Patients and the public were not involved in this study.

ABSTRACT

Objectives: In the past decade, China has been characterized by large-scale urbanization as well as rapid economic growth. The aim of this study was to further investigate the prevalence of hyperuricemia (HUA) in an eastern Chinese population.

Design: Cross-sectional study.

Setting: Survey of Prevalence in East China of Metabolic Diseases and Risk Factors (SPECT-China) study.

Participants: In this study, 12,770 residents from 22 sites in eastern China were recruited. Finally, 9,225 subjects were included.

Main outcome measures: The serum levels of uric acid, fasting plasma glucose (FPG), glycated hemoglobin (HbA1c) and other metabolic parameters were tested. Waist circumference (WC), weight, height and blood pressure were also measured. Questionnaires regarding smoking, drinking, education, etc., were collected from the subjects.

Results: The prevalence of HUA in this eastern Chinese population was 11.3% (9.9, 12.7) overall, 20.7% (17.7, 23.7) in men and 5.6% (4.3, 6.7) in women. The prevalence of HUA in urban subjects was higher than that in rural subjects (12.9 vs. 10.8%, $P<0.01$). The prevalence of HUA was negatively and positively associated with age in men and women, respectively. Residents with high body mass index (BMI) levels had a higher prevalence of HUA. In the logistic regression analysis, male sex, urban residency, total cholesterol (TC), triglyceride (TG), overweight, obesity, systolic blood pressure (SBP) and low economic status were independently correlated with HUA.

Conclusions: The estimated prevalence of HUA in this eastern Chinese population was 11.3% (9.9, 12.7) overall and 20.7% (17.7, 23.7) and 5.6% (4.3, 6.7) in men and women, respectively. HUA has gradually become an important public health issue in China.

Trial registration: ChiCTR-ECS-14005052.

Keywords: Prevalence, hyperuricemia, economic growth, public health, risk factors

Strengths and limitations of this study

- This is the largest published hyperuricemia study in an eastern Chinese population.
- This study covers residents from 22 sites in five provinces.
- This is a regional survey instead of a national study.
- This is a cross-sectional study that indicated an association between uric acid and other risk factors.
- We do not consider the influence of diet.

Abbreviations: HUA, hyperuricemia; FPG, fasting plasma glucose; WC; waist circumference; BMI, body mass index; LDL, low-density lipoprotein; TG, triglyceride; HDL, high-density lipoprotein; TC, total cholesterol; HbA1c, Glycated hemoglobin; SBP, systolic blood pressure; DBP, diastolic blood pressure; NAFLD, Nonalcoholic fatty liver disease; CKD, chronic kidney disease; NGT, Normal glucose tolerance; GDP, gross domestic product; HPLC, high-performance liquid chromatography

Introduction

In humans, uric acid (UA) is the end product of purine metabolism and is mainly excreted via the kidneys. Xanthine oxidoreductase catalyzes two enzymatic reactions, hypoxanthine to xanthine and xanthine to UA. Several conditions can influence the concentration of serum UA, including purine-rich food intake, neoplastic disease, cytotoxic drugs, obesity, hypertension, etc. [1-3].

Uric acid is reported to be associated with oxidative stress and inflammation [1, 4]. In patients with hyperuricemia (HUA), deposition of UA in joints and tissues promotes the occurrence of gout and chronic nephropathy. HUA has also been reported to be associated with insulin resistance, nonalcoholic fatty liver disease (NAFLD) [5, 6], metabolic syndrome, type 2 diabetes, atherosclerosis and coronary heart disease [7-11]. The overall prevalence of HUA in adults in the United States was 21.4% in 2007-2008 [12]. However, in Chinese adults, the adjusted prevalence of HUA in 2009-2010 was 8.4% [13]. In an elderly Chinese population, the overall prevalence of HUA was 13.1% [14]. Liu R et al [15] conducted a meta-analysis between 2000 and 2014 to determine the prevalence of HUA in mainland China. The pooled prevalence of HUA was 13.3% (male 19.4% and female 7.9%).

In the past decade, China has been characterized by large-scale urbanization. The percentage of the urban population rose from 18% in 1978 to 56% in 2015 [16]. As serum UA is closely related to economic development and urbanization [13], it is necessary to understand the latest prevalence of HUA in China.

China is characterized by regional and economic diversity. Eastern China has a relatively higher economic status than the rest of the country. In the present study, we performed a cross-sectional survey to investigate the prevalence of HUA and its risk factors in an eastern Chinese population.

Methods

Study population

Data from the current study are from the Survey of Prevalence in East China of Metabolic Diseases and Risk Factors (SPECT-China), which is a population-based cross-sectional survey of the prevalence of metabolic diseases and risk factors in eastern China [17]. The registration number is ChiCTR-ECS-14005052 (www.chictr.org). In this study, 12,770 residents from 22 sites in Shanghai, Zhejiang, Jiangsu, Anhui and Jiangxi provinces were enrolled from January 2014 to December 2015 (Supplemental Figure 1). The inclusion and exclusion criteria were described previously [17]. Chinese citizens more than 18 years old who had lived in their current area for more than 6 months were selected. We excluded subjects with severe communication problems, acute illness, or an unwillingness to participate. We also excluded residents who had no UA data (n=3,535) and chronic kidney disease (CKD) stage 5 (n=10). Finally, 9,225 subjects were included. This study was approved by the ethics committee of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine. Written consent was obtained from all the participants.

Measurements and definition

HUA was defined as serum UA >420 μmol/L for men and >360 μmol/L for women [18]. Blood pressure and heart rate were measured with a sphygmomanometer (TERUMO-Elemano) three times. The mean of the three records was used in the analysis. Hypertension was defined as a systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure (DBP) ≥ 90 mmHg or any self-reported history of hypertension. Diabetes was defined as a self-reported history of diabetes or glycated hemoglobin (HbA1c) levels of 6.5% or more. Prediabetes was defined as HbA1c concentrations between 5.7% and 6.4%. Normal glucose tolerance (NGT) was defined as an HbA1c less than 5.7% [19]. Weight and height were measured wearing light clothing and without shoes. Body mass index (BMI) was calculated as weight (kg)/height squared (m^2). Overweight was defined as 24 $kg/m^2 \leq BMI < 28$ kg/m^2. Obesity was defined as $BMI \geq 28$ kg/m^2. Waist circumference (WC) was measured at the level of 1 cm above the umbilicus. Demographic information and lifestyle risk factors were gathered from standard questionnaires by trained staff. Current smoking was defined as

having smoked at least 100 cigarettes in one's lifetime and currently smoking cigarettes [20]. Current drinking was defined as drinking more than once a month. Current economic status was assessed by the gross domestic product (GDP) per capita of 2013 at each study site. The mean national GDP per capita (6807 US dollars from World Bank) in 2013 was considered the cutoff point for economic status.

Assessment of biochemical indexes

Venous blood samples were drawn from all participants after fasting for at least 8 hours and immediately centrifuged (2000 rpm for 15 min) at room temperature. Blood samples were stored at -20ºC when collected and shipped by air in dry ice to one central laboratory certified by the College of American Pathologists within 2-4 hours of collection. All plasma and serum samples were frozen at -80ºC after laboratory testing. Serum UA was analyzed with a Beckman Coulter AU 680 device with the original kit (Brea, California, USA). The validity and accuracy of UA were 6% and 4%, respectively. Other biochemical indexes were analyzed as described previously [21].

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, Version 22 (IBM Corporation, Armonk, New York). Demographic and metabolic characteristics are expressed as the mean ± SD for continuous variables and percentages (95% CI) for categorical variables in the overall population and in subgroups of location, age, economic status, BMI and glucose status. Logistic analysis was used to investigate the association of demographic, lifestyle, and metabolic factors with the odds of HUA. According to the 6th national population census data, the proportions of the population in different age groups (<40, 40-60, ≥60) are 57.39%, 29.29%, and 13.31% (total); 58.10%, 29.13%, and 12.76% (male); and 56.61%, 29.46%, and 13.91% (female), respectively (http://www.stats.gov.cn/tjsj/pcsj/rkpc/6rp/indexce.htm). Thus, we adjusted the prevalence of HUA by these proportions. All analyses were two-sided. $P<0.05$ was considered significant.

Results

Characteristics of this eastern Chinese population

In our study, we analyzed UA in 9,225 Chinese adults, including 3,682 males (age, 55.57±13.23 y) and 5,543 females (age 54.30±12.82 y). The mean levels of serum UA were 352.12±79.30 nmol/L and 269.29±64.68 nmol/L in males and females, respectively. There were significant sex differences in blood glucose, blood lipids, UA, BMI, WC and blood pressure. The prevalence of diabetes and hypertension also showed a significant difference (Table 1).

Metabolic risk factors of this eastern Chinese population

The prevalence of diabetes and hypertension, WC, SBP and BMI increased with age. As BMI and glucose levels rose, the prevalence of hypertension, WC, SBP, BMI, triglyceride (TG), FPG, and HbA1c increased. Moreover, people living in rural areas had a higher prevalence of diabetes, WC, SBP, low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol (TC) and HbA1c. People with a high economic status had a higher prevalence of diabetes, WC, UA, BMI, LDL, FPG, HbA1c and Cr (Tables 2, 3).

Estimated prevalence of HUA in this eastern Chinese population

The prevalence of HUA was 12.3% (11.6, 12.9), with 17.9% (16.7, 19.1) and 8.5% (7.8, 9.3) in males and females, respectively. The prevalence of HUA in urban areas was higher than that in rural areas (12.9% vs. 10.8%). The prevalence of HUA in developed areas was slightly higher than that in underdeveloped areas (12.6% vs. 11.8%). As BMI increased, the prevalence of HUA increased in both men and women. In women, the prevalence of HUA increased in normal, prediabetic and diabetic populations. However, this trend was not obvious in men. After adjusting for the proportions of the population in different age groups, the prevalence of HUA was 11.3% (9.9, 12.7), with 20.7% (17.7, 23.7) and 5.6% (4.3, 6.7) in males and females, respectively (Table 4). When HUA was defined as serum UA of more than 420 μmol/L in both men and women, the prevalence of HUA was 8.4% (7.8, 9.0), with 17.9% (16.7, 19.1) and 2.1% (1.7, 2.5) in males and females, respectively. After adjusting for the proportions of the population in different age groups, the prevalence of HUA was 8.8%

(7.5, 10.1), with 20.7% (17.7, 23.7) and 1.4% (0.7, 2.0) in males and females, respectively (Supplemental Table 1).

Logistic regression analysis of HUA

Male sex, urban residency, increased TC or TG, overweight, obesity, elevated SBP and low economic status were all risk factors for HUA in this eastern Chinese population (Table 5). However, increased age, higher educational status, increased LDL or HDL, current smoking or drinking and elevated DBP were not associated with the risk of_HUA. When HUA was defined as serum UA of more than 420 μmol/L in both men and women, the association was similar to the above results (Supplemental Table 2).

Discussion

In this eastern Chinese population, the prevalence of HUA was 11.3%, which was similar to the pooled prevalence reported in a systematic review performed in China (13.3%) [15]. However, this prevalence was more than that in the national HUA survey, which reported that the prevalence of HUA was 8.4% [13]. The previous survey was performed in 2009-2010. Our study occurred in 2014-2015. These two studies investigated different populations. In addition, our prevalence was relatively lower than that in Qingdao, which is close to the sea and where residents consume high amounts of seafood and beer [22]. Moreover, the prevalence of HUA in our population was lower than those in the United States and Japan [12, 23], which might be attributed to economic status.

The prevalence of HUA in young men (<40 years) was seven times greater than that in young women. However, as age increased, the prevalence of HUA gradually decreased in men and increased in women, which was coincident with values previously reported [24]. In residents more than 60 years of age, men and women had a similar prevalence of HUA. We deduced that the diet of young men contains more purine than that of old men. The young men also had an active metabolism. The prevalence of HUA was dramatically increased in women older than 60 years, which might be caused by reduced estrogen levels.

Risk factors for HUA were also evaluated in our study. We found that male sex, urban residency, hypertriglyceridemia, hypercholesterolemia, overweight, obesity, high SBP and low economic status were risk factors for HUA. In previous studies, hypertriglyceridemia was thought to be the strongest risk factor for HUA [24, 25]. However, the OR for HUA was 1.7 times with 1 SD elevation of triglyceridemia. In addition, obesity was the strongest risk factor (OR=2.874) in our study. China has the largest obese population in the world [26]. In this case, the prevalence of HUA will increase with the rising trend of obesity. Therefore, we should pay more attention to prevent its consequences.

HUA is closely related to lifestyle and dietary habits. In previous studies, the prevalence of HUA in urban areas was much greater than that in rural areas [13, 24]. In our study, the prevalence of HUA in urban areas was mildly elevated (12.9% vs. 10.8%), and urbanization was a risk factor for HUA. Eastern China is considered the developed area in the whole country. Therefore, the difference between urban and rural areas was not obvious as in other

places. Moreover, people with high economic status consumed more healthy food that contained low purine ingredients. This could partly explain why low economic status became a risk factor for HUA. In accordance with a previous study, smoking was not associated with HUA [13]. However, according to a previous study, alcohol intake influences serum UA, which is different from the results of our study. This difference might have been caused by our definition of current drinking (current drinking was defined as drinking in the past 1 month), which mixed nonhabitual drinkers and habitual drinkers together.

As age increased, UA together with components of metabolic syndrome (FPG, SBP, WC) also increased, which indicated that there might be a close relationship between metabolic syndrome and HUA. Other studies have also found that HUA is associated with metabolic syndrome [27, 28]. An epidemiologic study showed that HUA is positively correlated with fasting serum insulin [29]. Krishnan et al reported that people with HUA have 1.36 times the risk of developing insulin resistance in a 15-year follow-up study [30]. Thus, research has indicated that insulin resistance plays an important role in the relationship between metabolic syndrome and HUA [31].

There were several limitations in our study. First, this was not a national study but a local survey. Second, we did not consider the influence of diet. Blood was drawn after fasting for eight hours. However, the diet ingested near the blood drawing time was unknown. In addition, this was a cross-sectional study. Therefore, we could not identify a causal relationship between HUA and its risk factors.

In this study, we estimated the prevalence of HUA in an eastern Chinese population. To prevent the prevalence of HUA, more attention should be paid to life status (such as economic status and residence) and metabolic indexes (TC, TG, BMI, and SBP).

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Figure legend

Supplemental Figure 1 Position of the 5 provinces and 22 sites in China.

Residents from 22 sites in Shanghai, Zhejiang, Jiangsu, Anhui and Jiangxi provinces were enrolled in SPECT-China study.

Table 1 Baseline characteristics between different groups.

Variables	Men (n=3682)	Women (n=5543)	P value
Age y	55.57±13.23	54.30±12.82	<0.001
FPG mmol/L	5.72±1.63	5.50±1.36	<0.001
HbA1c %	5.78±1.08	5.64±0.92	<0.001
TG mmol/L	1.88±1.79	1.55±1.20	<0.001
TC mmol/L	5.14±1.13	5.27±1.15	<0.001
LDL mmol/L	3.23±0.77	3.30±0.83	<0.001
HDL mmol/L	1.30±0.31	1.45±0.32	<0.001
UA umol/L	352.1±79.3	269.3±64.7	<0.001
BMI kg/m^2	25.11±3.45	24.40±3.67	<0.001
WC cm	85.85±9.42	78.72±9.90	<0.001
SBP mmHg	134.3±20.7	131.1±22.2	<0.001
DBP mmHg	82.1±12.9	77.8±12.9	<0.001
Diabetes %	16.3%	12.7%	<0.001
Hypertension %	53.4%	44.1%	<0.001

Uric acid: UA; Fasting plasma glucose: FPG; Alanine aminotransferase: ALT; Triglycerides: TG; Total cholesterol: TC; Body mass index: BMI; Waist circumference: WC; Systolic blood pressure: SBP; Diastolic blood pressure: DBP

Table 2 Characteristics of Eastern Chinese population.

	Percentage % (95%CI)				Means±SD		
	Diabetes	Hypertension	Smoking	Drinking	WC	SBP	BMI
Overall	14.1 (13.4, 14.8)	47.8 (46.8, 48.9)	19.2 (18.3, 20.0)	55.8 (54.8, 56.9)	81.57±10.32	132.4±21.7	24.68±3.60
Location							
Rural	15.8 (14.4, 17.2)	58.7 (56.8, 60.6)	22.9 (21.3, 24.5)	56.6 (54.7, 58.5)	83.14±10.38	139.7±23.2	24.71±3.65
Urban	13.4 (12.6, 14.2)	43.3 (42.1, 44.5)	17.6 (16.7, 18.6)	55.5 (54.3, 56.7)	80.90±10.23	129.4±20.3	24.67±3.58
Age groups							
<40	1.6 (0.9, 2.3)	11.1 (9.4, 12.9)	12.9 (11.0, 14.8)	42.0 (39.2, 44.7)	75.22±10.55	116.8±15.0	23.38±3.61
40-60	11.3 (10.3, 12.2)	41.8 (40.3, 43.3)	20.8 (19.6, 22.0)	54.9 (53.4, 56.5)	80.78±9.87	129.5±20.1	24.82±3.35
>=60	21.5 (20.2, 22.9)	67.1 (65.6, 68.7)	19.4 (18.1, 20.7)	61.5 (59.9, 63.1)	84.60±9.59	141.0±21.5	24.96±3.79
Economic status							
low	12.3 (11.3, 13.3)	47.8 (46.3, 49.4)	21.2 (19.9, 22.5)	46.6 (45.1, 48.2)	81.07±10.57	134.2±23.5	24.50±3.55
high	15.6 (14.6, 16.6)	47.8 (46.4, 49.2)	17.6 (16.5, 18.6)	62.9 (61.6, 64.3)	81.96±10.10	131.0±20.1	24.83±3.64
BMI							
<24	9.8 (8.9, 10.7)	35.2 (33.7, 36.7)	16.6 (15.4, 17.7)	52.9 (51.3, 54.5)	74.72±7.85	126.9±21.1	21.67±1.69
24-28	15.2 (14.0, 16.4)	53.0 (51.4, 54.7)	20.6 (19.2, 21.9)	58.3 (56.7, 59.9)	84.57±7.30	135.2±21.2	25.79±1.12
>=28	24.1 (21.8, 26.3)	69.1 (66.7, 71.5)	22.8 (20.6, 25.0)	57.6 (55.0, 60.2)	93.34±8.52	140.5±20.2	30.40±3.09
Glucose status							
normal	-	37.0 (35.6, 38.3)	16.2 (15.1, 17.2)	50.6 (49.3, 52.0)	78.95±9.88	128.0±20.6	24.08±3.44
prediabetes	-	57.6 (55.7, 59.5)	23.4 (21.7, 25.0)	63.2 (61.3, 65.1)	83.90±9.53	136.7±21.6	25.26±3.55
diabetes	-	72.7 (70.3, 75.2)	23.0 (20.6, 25.3)	61.3 (58.7, 64.0)	87.60±9.97	141.9±21.2	26.00±3.78

Body mass index: BMI; Waist circumference: WC; Systolic blood pressure: SBP

Table 3 Biochemical index of Eastern Chinese population.

	Means±SD							
	UA	LDL	TG	HDL	TC	FPG	HbA1c	Creatinine
Overall	302.0±81.5	3.28±0.81	1.68 ±1.48	1.39 ±0.32	5.22 ±1.14	5.58±1.48	5.70±0.99	77.31±14.96
Location								
Rural	294.8±83.0	3.38±0.83	1.69±1.56	1.44±0.31	5.37±1.07	5.63±1.60	5.80±1.03	73.76±14.20
Urban	305.6±80.9	3.23±0.80	1.67±1.43	1.37±0.33	5.16±1.17	5.57±1.42	5.65±0.96	78.87±15.13
Age groups								
<40	294.1±85.7	2.81±0.65	1.35±1.25	1.39±0.30	4.60±0.87	4.98±0.76	5.09±0.57	75.82±14.73
40-60	298.0±82.8	3.29±0.78	1.76±1.71	1.39±0.32	5.24±1.16	5.52±1.46	5.62±0.94	76.26±14.59
>=60	310.1±78.3	3.42±0.83	1.69±1.20	1.38±0.34	5.39±1.13	5.86±1.60	5.98±1.04	79.09±15.47
Economic status								
low	299.8±85.1	3.23±0.82	1.70±1.65	1.45±0.32	5.20±1.05	5.54±1.48	5.62±0.99	76.29±15.23
high	304.4±78.7*	3.31±0.80*	1.66±1.31	1.34±0.32*	5.23±1.21	5.62±1.47*	5.75±0.98*	78.20±14.83*
BMI								
<24	279.5±73.3	3.15±0.80	1.35±1.05	1.48±0.33	5.11±1.09	5.39±1.35	5.53±0.92	75.83±14.26
24-28	313.9±81.7	3.36±0.81	1.85±1.50	1.33±0.30	5.28±1.18	5.64±1.47	5.76±0.99	78.34±15.37
>=28	335.5±85.3	3.44±0.80	2.20±2.13	1.27±0.28	5.39±1.17	6.00±1.74	6.02±1.10	78.95±15.44
Glucose status								
normal	294.9±81.3	3.12±0.76	1.54±1.38	1.41±0.32	5.05±1.10	5.09±0.54	5.16±0.36	76.81±14.77
prediabetes	313.1±81.1	3.51±0.81	1.71±1.17	1.38±0.32	5.49±1.12	5.45±0.72	5.93±0.20	77.95±14.83
diabetes	310.9±81.2	3.42±0.86	2.18±2.14	1.29±0.32	5.38±1.21	7.89±2.63	7.38±1.49	78.22±16.38

Uric acid: UA; Triglycerides: TG; Total cholesterol: TC; Low-density lipoprotein: LDL; High-density lipoprotein: HDL; Glycated hemoglobin: HbA1c; Fasting plasma glucose: FPG

Table 4 Estimated prevalence of HUA in Eastern Chinese population.

	Percentage % (95%CI)		
	Overall	Men	Women
Overall	12.3 (11.6, 12.9)	17.9 (16.7-19.1)	8.5 (7.8-9.3)
Overall*	11.3 (9.9, 12.7)	20.7 (17.7, 23.7)	5.6 (4.3, 6.7)
Location			
Urban	12.9 (12.1, 13.7)	19.1 (17.6-20.7)	8.9 (8.0-9.8)
Rural	10.8 (9.6, 12.0)	15.2 (13.1-17.3)	7.7 (6.4-9.0)
Age groups			
<40	10.8 (9.0, 12.5)	22.8 (19.0, 26.6)	3.3 (2.0, 4.5)
40-60	11.2 (10.3, 12.2)	18.9 (17.0, 20.8)	6.5 (5.5, 7.4)
>=60	13.9 (12.8, 15.0)	15.4 (13.6, 17.2)	12.8 (11.4, 14.2)
Economic status			
low	11.8 (10.9-12.8)	18.3 (16.5-20.1)	7.2 (6.1-8.2)
high	12.6 (11.7-13.5)	17.5 (15.8-19.2)	9.5 (8.5-10.6)
BMI			
<24	6.7 (5.9, 7.5)	10.5 (8.9, 12.2)	4.8 (3.9, 5.6)
24-28	14.1 (13.0, 15.3)	19.9 (18.0, 21.9)	9.4 (8.1, 10.7)
>=28	22.5 (20.3, 24.6)	27.3 (23.9, 30.8)	18.5 (15.7, 21.2)
Glucose status			
normal	10.1 (9.3-10.9)	17.5 (15.8-19.2)	5.7 (4.9-6.5)
prediabetes	15.2 (13.9-16.6)	20.3 (17.9-22.7)	11.6 (10.0-13.2)
diabetes	15.1 (13.1-17.0)	15.0 (12.1-17.8)	15.2 (12.5-17.9)

Body mass index: BMI

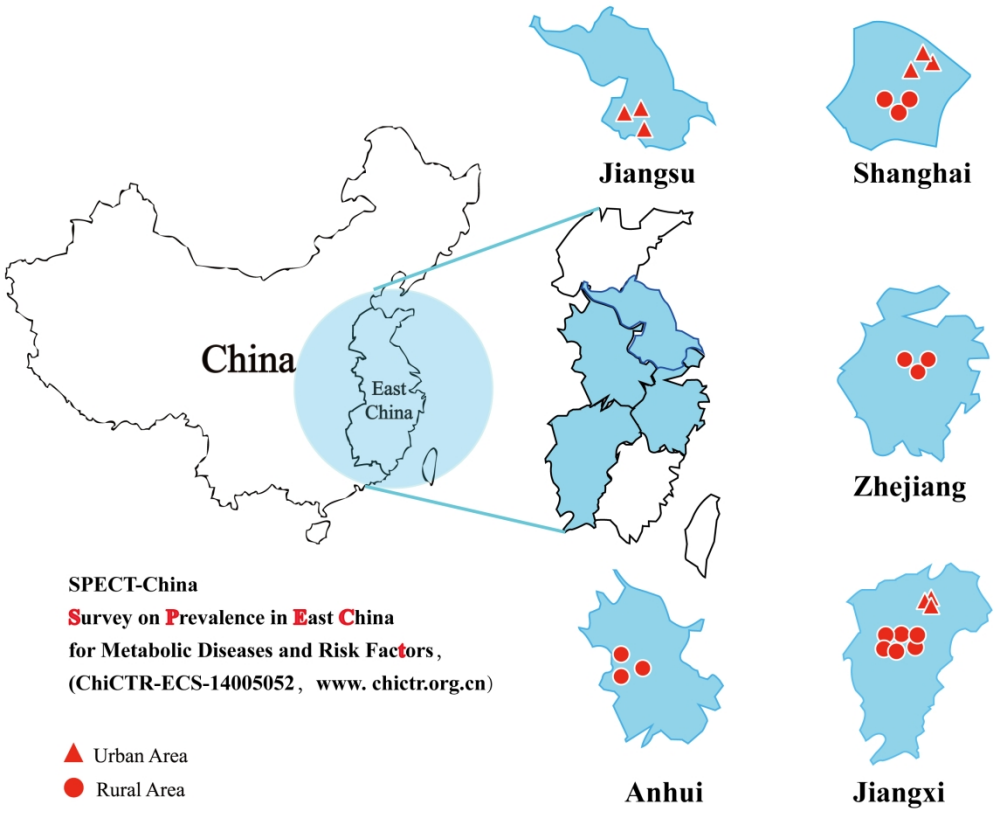
* standardized by proportions of population of 6th national population census data

Table 5 Risk factors for HUA in Eastern Chinese population.

Risk factors	OR	(95%CI)
Female sex	0.510	0.427, 0.609
Age per 10 years	1.041	0.976, 1.112
Urban residency	2.218	1.681, 2.927
≥Junior middle school education	1.042	0.866, 1.253
Lipids		
LDL per 1SD	1.018	0.888, 1.168
HDL per 1SD	0.936	0.850, 1.032
TC per 1SD	1.226	1.050, 1.432
TG per 1SD	1.672	1.491, 1.875
Current smoking	0.942	0.778,1.141
Current drinking	0.913	0.784,1.062
BMI		
Overweight	1.772	1.481, 2.120
Obesity	2.874	2.338, 3.532
Blood pressure		
SBP per 10mmHg	1.055	1.009, 1.103
DBP per 10mmHg	1.012	0.944, 1.085
High economic status	0.688	0.538, 0.879

Data are expressed as unStandardized B (95%CI). The enter procedure was used.

Body mass index: BMI



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Supplemental Table 1 Estimated prevalence of HUA (UA>420μmol/L) in Eastern Chinese population.

	Percentage % (95%CI)		
	Overall	Men	Women
Overall	8.4 (7.8, 9.0)	17.9 (16.7, 19.1)	2.1 (1.7, 2.5)
Overall*	8.8 (7.5, 10.1)	20.7 (17.7, 23.7)	1.4 (0.7, 2.0)
Location			
Urban	8.8 (8.1, 9.5)	19.1 (17.6-20.7)	2.1 (1.7, 2.6)
Rural	7.5 (6.5, 8.5)	15.2 (13.1-17.3)	1.9 (1.3, 2.6)
Age groups			
<40	9.3 (7.7, 10.9)	22.8 (19.0, 26.6)	0.9 (0.2, 1.6)
40-60	8.0 (7.2, 8.8)	18.9 (17.0, 20.8)	1.3 (0.8, 1.7)
>=60	8.5 (7.6, 9.4)	15.4 (13.6, 17.2)	3.5 (2.7, 4.2)
Economic status			
low	8.6 (7.7, 9.5)	18.3 (16.5-20.1)	1.6 (1.1, 2.0)
high	8.2 (7.5, 9.0)	17.5 (15.8-19.2)	2.5 (1.9, 3.0)
BMI			
<24	4.2 (3.6, 4.8)	10.5 (8.9, 12.2)	0.9 (0.6, 1.3)
24-28	10.1 (9.1, 11.1)	19.9 (18.0, 21.9)	2.1 (1.4, 2.7)
>=28	15.7 (13.8, 17.6)	27.3 (23.9, 30.8)	6.0 (4.4, 7.7)
Glucose status			
normal	7.3 (6.6, 8.0)	17.5 (15.8, 19.2)	1.1 (0.8, 1.5)
prediabetes	10.3 (9.1, 11.4)	20.3 (17.9, 22.7)	3.1 (2.2, 3.9)
diabetes	9.4 (7.8, 10.9)	15.0 (12.1, 17.8)	4.6 (3.0, 6.1)

Body mass index: BMI

* standardized by proportions of population of 6th national population census data

Supplemental table 2 Risk factors for HUA (UA>420μmol/L) in Eastern Chinese population.

Risk factors	OR	(95%CI)
Female sex	0.110	0.086, 0.142
Age per 10 years	0.937	0.867, 1.013
Urban residency	2.292	1.654, 3.176
≥Junior middle school education	1.037	0.835, 1.288
Lipids		
LDL per 1SD	1.014	0.861, 1.193
HDL per 1SD	0.984	0.873, 1.109
TC per 1SD	1.209	1.004, 1.456
TG per 1SD	1.724	1.504, 1.978
Current smoking	0.921	0.755, 1.123
Current drinking	1.008	0.841, 1.209
BMI		
Overweight	1.812	1.448, 2.268
Obesity	2.835	2.191, 3.668
Blood pressure		
SBP per 10mmHg	1.082	1.023, 1.145
DBP per 10mmHg	1.017	0.932, 1.109
High economic status	0.670	0.504, 0.890

Data are expressed as unStandardized B (95%CI). The enter procedure was used.

Body mass index: BMI

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1,4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	Not Applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8,9
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8,9
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Not Applicable
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Not Applicable
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Not Applicable
		Cross-sectional study—Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10,11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other Information			

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of hyperuricemia in an eastern Chinese population: a cross-sectional study

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Prevalence of hyperuricemia in an eastern Chinese population: a cross-sectional study

Bing Han*, Ningjian Wang, Yi Chen, Qin Li, Chunfang Zhu, Yingchao Chen and Yingli Lu*

Institute and Department of Endocrinology and Metabolism, Shanghai Ninth People's Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China

Correspondance: Dr Yingli Lu, luyingli2008@126.com and Bing Han, hanbing1423@163.com.

Running title: Prevalence of hyperuricemia in China.

ABSTRACT

Objectives: In the past decade, China has been characterized by large-scale urbanization as well as rapid economic growth. The aim of this study was to further investigate the prevalence of hyperuricemia (HUA) in an eastern Chinese population.

Design: Cross-sectional study.

Setting: Survey of Prevalence in East China of Metabolic Diseases and Risk Factors (SPECT-China) study.

Participants: In this study, 12,770 residents from 22 sites in eastern China were recruited. Finally, 9,225 subjects were included.

Main outcome measures: The serum levels of uric acid, fasting plasma glucose (FPG), glycated hemoglobin (HbA1c) and other metabolic parameters were tested. Waist circumference (WC), weight, height and blood pressure were also measured. Questionnaires regarding smoking, drinking, education, etc., were collected from the subjects. HUA was defined as serum UA >420 μmol/L for men and >360 μmol/L for women.

Results: The prevalence of HUA in this eastern Chinese population was 11.3% (9.9, 12.7) overall, 20.7% (17.7, 23.7) in men and 5.6% (4.3, 6.7) in women. The prevalence of HUA in urban subjects was higher than that in rural subjects (12.9 vs. 10.8%, $P<0.01$). The prevalence of HUA was negatively and positively associated with age in men and women, respectively. Residents with high body mass index (BMI) levels had a higher prevalence of HUA. In the logistic regression analysis, male sex, urban residency, total cholesterol (TC), triglyceride (TG), overweight, obesity, systolic blood pressure (SBP) and low economic status were independently correlated with HUA.

Conclusions: The estimated prevalence of HUA in this eastern Chinese population was 11.3% (9.9, 12.7) overall and 20.7% (17.7, 23.7) and 5.6% (4.3, 6.7) in men and women, respectively. HUA has gradually become an important public health issue in China.

Trial registration: ChiCTR-ECS-14005052.

Keywords: Prevalence, hyperuricemia, economic growth, public health, risk factors

Strengths and limitations of this study

This is the largest published hyperuricemia study in an eastern Chinese population.

This study covers residents from 22 sites in five provinces.

This is a regional survey instead of a national study.

We do not consider the influence of diet.

Abbreviations: HUA, hyperuricemia; FPG, fasting plasma glucose; WC; waist circumference; BMI, body mass index; LDL, low-density lipoprotein; TG, triglyceride; HDL, high-density lipoprotein; TC, total cholesterol; HbA1c, Glycated hemoglobin; SBP, systolic blood pressure; DBP, diastolic blood pressure; NAFLD, Nonalcoholic fatty liver disease; CKD, chronic kidney disease; NGT, Normal glucose tolerance; GDP, gross domestic product; HPLC, high-performance liquid chromatography

Introduction

In humans, uric acid (UA) is the end product of purine metabolism and is mainly excreted via the kidneys. Xanthine oxidoreductase catalyzes two enzymatic reactions, hypoxanthine to xanthine and xanthine to UA. Several conditions can influence the concentration of serum UA, including purine-rich food intake, neoplastic disease, cytotoxic drugs, obesity, hypertension, etc. [1-3].

Uric acid is reported to be associated with oxidative stress and inflammation [1, 4]. In patients with hyperuricemia (HUA), deposition of UA in joints and tissues promotes the occurrence of gout and chronic nephropathy. HUA has also been reported to be associated with insulin resistance, nonalcoholic fatty liver disease (NAFLD) [5, 6], metabolic syndrome, type 2 diabetes, atherosclerosis and coronary heart disease [7-11]. The overall prevalence of HUA in adults in the United States was 21.4% in 2007-2008 [12]. In Henan Rural Cohort Study conducted from 2015 to 2017, the crude and age-standardized prevalence of HUA were 10.24% and 12.60%, respectively[13]. In 2017, Chen Y et al found that the prevalence of HUA was 13.4% in Jidong community of Tangshan City in northern China[14]. In an elderly Chinese population of 7 areas, the overall prevalence of HUA was 13.1% in 2018 [15]. Liu R et al [16] also conducted a meta-analysis including 38 regional studies between 2000 and 2014 to determine the prevalence of HUA in mainland China. The pooled prevalence of HUA was 13.3% (male 19.4% and female 7.9%). These studies were all local or regional investigations. There were also two national cross-sectional surveys using multistage, stratified sampling. In 2009-2010, Liu H et al showed the adjusted prevalence of HUA was 8.4% in Chinese adults [17]. Recently, Lu X et al conducted a nationwide survey in 31 provinces in China. The prevalence of HUA were 13.7%-18.8% based on different urine iodine concentrations[18].

In the past decade, China has been characterized by large-scale urbanization. The percentage of the urban population rose from 18% in 1978 to 56% in 2015 [19]. As serum UA is closely related to economic development and urbanization [13], it is necessary to understand the latest prevalence of HUA in China.

China is characterized by regional and economic diversity. Eastern China has a relatively higher economic status than the rest of the country. In the present study, we performed a

cross-sectional survey to investigate the prevalence of HUA and its risk factors in an eastern Chinese population.

Methods

Study population

Data from the current study are from the Survey of Prevalence in East China of Metabolic Diseases and Risk Factors (SPECT-China), which is a population-based cross-sectional survey of the prevalence of metabolic diseases and risk factors in eastern China [20]. The registration number is ChiCTR-ECS-14005052 (www.chictr.org). In this study, 12,770 residents from 22 sites in Shanghai, Zhejiang, Jiangsu, Anhui and Jiangxi provinces were enrolled from January 2014 to December 2015 (Supplemental Figure 1). The inclusion and exclusion criteria were described previously [20]. Chinese citizens more than 18 years old who had lived in their current area for more than 6 months were selected. We excluded subjects with severe communication problems, acute illness, or an unwillingness to participate. We also excluded residents who had no UA data (n=3,535) and chronic kidney disease (CKD) stage 5 (n=10). Finally, 9,225 subjects were included. This study was approved by the ethics committee of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine. Written consent was obtained from all the participants.

Measurements and definition

HUA was defined as serum UA >420 μmol/L for men and >360 μmol/L for women [21]. Blood pressure and heart rate were measured with a sphygmomanometer (TERUMO-Elemano) three times. The mean of the three records was used in the analysis. Hypertension was defined as a systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure (DBP) ≥ 90 mmHg or any self-reported history of hypertension. Diabetes was defined as a self-reported history of diabetes or glycated hemoglobin (HbA1c) levels of 6.5% or more. Prediabetes was defined as HbA1c concentrations between 5.7% and 6.4%. Normal glucose tolerance (NGT) was defined as an HbA1c less than 5.7% [22]. Weight and height were measured wearing light clothing and without shoes. Body mass index (BMI) was calculated as weight (kg)/height squared (m^2). Overweight was defined as 24 $kg/m^2 \leq BMI < 28$ kg/m^2. Obesity was defined as $BMI \geq 28$ kg/m^2. Waist circumference (WC) was measured at the level of 1 cm above the umbilicus. Demographic information and lifestyle risk factors were gathered from standard questionnaires by trained staff. Current smoking was defined as

having smoked at least 100 cigarettes in one's lifetime and currently smoking cigarettes [23]. Current drinking was defined as drinking more than once a month. Current economic status was assessed by the gross domestic product (GDP) per capita of 2013 at each study site. The mean national GDP per capita (6807 US dollars from World Bank) in 2013 was considered the cutoff point for economic status.

Assessment of biochemical indexes

Venous blood samples were drawn from all participants after fasting for at least 8 hours and immediately centrifuged (2000 rpm for 15 min) at room temperature. Blood samples were stored at -20ºC when collected and shipped by air in dry ice to one central laboratory certified by the College of American Pathologists within 2-4 hours of collection. All plasma and serum samples were frozen at -80ºC after laboratory testing. Serum UA was analyzed with a Beckman Coulter AU 680 device with the original kit (Brea, California, USA). The validity and accuracy of UA were 6% and 4%, respectively. Other biochemical indexes were analyzed as described previously [24].

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, Version 22 (IBM Corporation, Armonk, New York). Demographic and metabolic characteristics are expressed as the mean ± SD for continuous variables and percentages (95% CI) for categorical variables in the overall population and in subgroups of location, age, economic status, BMI and glucose status. Logistic analysis was used to investigate the association of demographic, lifestyle, and metabolic factors with the odds of HUA. According to the 6th national population census data, the proportions of the population in different age groups (<40, 40-60, ≥60) are 57.39%, 29.29%, and 13.31% (total); 58.10%, 29.13%, and 12.76% (male); and 56.61%, 29.46%, and 13.91% (female), respectively [25]. Thus, we adjusted the prevalence of HUA by these proportions. All analyses were two-sided. $P<0.05$ was considered significant.

Results

Characteristics of this eastern Chinese population

In our study, we analyzed UA in 9,225 Chinese adults, including 3,682 males (age, 55.57±13.23 y) and 5,543 females (age 54.30±12.82 y). The mean levels of serum UA were 352.12±79.30 nmol/L and 269.29±64.68 nmol/L in males and females, respectively. There were significant sex differences in blood glucose, blood lipids, UA, BMI, WC and blood pressure. The prevalence of diabetes and hypertension also showed a significant difference (Table 1).

Metabolic risk factors of this eastern Chinese population

The prevalence of diabetes and hypertension, WC, SBP and BMI increased with age. As BMI and glucose levels rose, the prevalence of hypertension, WC, SBP, BMI, triglyceride (TG), FPG, and HbA1c increased. Moreover, people living in rural areas had a higher prevalence of diabetes, WC, SBP, low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol (TC) and HbA1c. People with a high economic status had a higher prevalence of diabetes, WC, UA, BMI, LDL, FPG, HbA1c and Cr (Tables 2, 3).

Estimated prevalence of HUA in this eastern Chinese population

The prevalence of HUA was 12.3% (11.6, 12.9), with 17.9% (16.7, 19.1) and 8.5% (7.8, 9.3) in males and females, respectively. The prevalence of HUA in urban areas was higher than that in rural areas (12.9% vs. 10.8%). The prevalence of HUA in developed areas was slightly higher than that in underdeveloped areas (12.6% vs. 11.8%). As BMI increased, the prevalence of HUA increased in both men and women. The prevalence of HUA in normal, prediabetic and diabetic women were 5.7% (4.9, 6.5), 11.6% (10.0, 13.2) and 15.2% (12.5, 17.9) respectively (Table 4). So there was an increased trend of prevalence of HUA in women with different glucose status. However, this trend was not obvious in men. After adjusting for the proportions of the population in different age groups, the prevalence of HUA was 11.3% (9.9, 12.7), with 20.7% (17.7, 23.7) and 5.6% (4.3, 6.7) in males and females, respectively (Table 4).

Logistic regression analysis of HUA

Male sex, urban residency, increased TC or TG, overweight, obesity, elevated SBP and low economic status were all risk factors for HUA in this eastern Chinese population (Table 5). However, increased age, higher educational status, increased LDL or HDL, current smoking or drinking and elevated DBP were not associated with the risk of HUA.

Discussion

In this eastern Chinese population, the prevalence of HUA was 11.3%, which was similar to the pooled prevalence reported in a systematic review performed in China (13.3%) [15]. However, this prevalence was more than that in the national HUA survey, which reported that the prevalence of HUA was 8.4% [13]. The previous survey was performed in 2009-2010. Our study occurred in 2014-2015. These two studies investigated different populations. In addition, our prevalence was relatively lower than that in Qingdao, which is close to the sea and where residents consume high amounts of seafood and beer [26]. Moreover, the prevalence of HUA in our population was lower than those in the United States and Japan [12, 27], which might be attributed to economic status.

The prevalence of HUA in young men (<40 years) was seven times greater than that in young women. However, as age increased, the prevalence of HUA gradually decreased in men and increased in women, which was coincident with values previously reported [28]. In residents more than 60 years of age, men and women had a similar prevalence of HUA. We deduced that the diet of young men contains more purine than that of old men. The young men also had an active metabolism. The prevalence of HUA was dramatically increased in women older than 60 years, which might be caused by reduced estrogen levels.

Risk factors for HUA were also evaluated in our study. We found that male sex, urban residency, hypertriglyceridemia, hypercholesterolemia, overweight, obesity, high SBP and low economic status were risk factors for HUA. In previous studies, hypertriglyceridemia was thought to be the strongest risk factor for HUA [28, 29]. However, the OR for HUA was 1.7 times with 1 SD elevation of triglyceridemia. In addition, obesity was the strongest risk factor (OR=2.874) in our study. China has the largest obese population in the world [30]. In this case, the prevalence of HUA will increase with the rising trend of obesity. Therefore, we should pay more attention to prevent its consequences.

HUA is closely related to lifestyle and dietary habits. In previous studies, the prevalence of HUA in urban areas was much greater than that in rural areas [13, 28]. In our study, the prevalence of HUA in urban areas was mildly elevated (12.9% vs. 10.8%), and urbanization was a risk factor for HUA. Eastern China is considered the developed area in the whole country. Therefore, the difference between urban and rural areas was not obvious as in other

places. Moreover, people with high economic status consumed more healthy food that contained low purine ingredients. This could partly explain why low economic status became a risk factor for HUA. In accordance with a previous study, smoking was not associated with HUA [13]. However, according to a previous study, alcohol intake influences serum UA, which is different from the results of our study. This difference might have been caused by our definition of current drinking (current drinking was defined as drinking in the past 1 month), which mixed nonhabitual drinkers and habitual drinkers together.

As age increased, UA together with components of metabolic syndrome (FPG, SBP, WC) also increased, which indicated that there might be a close relationship between metabolic syndrome and HUA. Other studies have also found that HUA is associated with metabolic syndrome [31, 32]. An epidemiologic study showed that HUA is positively correlated with fasting serum insulin [33]. Krishnan et al reported that people with HUA have 1.36 times the risk of developing insulin resistance in a 15-year follow-up study [34]. Thus, research has indicated that insulin resistance plays an important role in the relationship between metabolic syndrome and HUA [35].

There were several limitations in our study. First, this was not a national study but a local survey. Second, we did not consider the influence of diet. Blood was drawn after fasting for eight hours. However, the diet ingested near the blood drawing time was unknown. In addition, this was a cross-sectional study. Therefore, we could not identify a causal relationship between HUA and its risk factors.

In this study, we estimated the prevalence of HUA in an eastern Chinese population. To prevent the prevalence of HUA, more attention should be paid to life status (such as economic status and residence) and metabolic indexes (TC, TG, BMI, and SBP).

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Contributors

YL and BH designed and supervised this investigation. BH performed this investigation. YC, CFZ and YCC contributed to the data collection. NJW and QL provided technical or material support. All authors read and approved the final manuscript.

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Competing interests

The authors have declared that no competing interests exist.

Patient consent for publication

Not required

Ethical approval

The study protocol was approved by the Institutional Review Board of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

Data are available upon request to corresponding author.

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Figure legend

Supplemental Figure 1 Position of the 5 provinces and 22 sites in China.

Residents from 22 sites in Shanghai, Zhejiang, Jiangsu, Anhui and Jiangxi provinces were enrolled in SPECT-China study.

Table 1 Baseline characteristics between different groups.

Variables	Men (n=3682)	Women (n=5543)	P value
Age y	55.57±13.23	54.30±12.82	<0.001
FPG mmol/L	5.72±1.63	5.50±1.36	<0.001
HbA1c %	5.78±1.08	5.64±0.92	<0.001
TG mmol/L	1.88±1.79	1.55±1.20	<0.001
TC mmol/L	5.14±1.13	5.27±1.15	<0.001
LDL mmol/L	3.23±0.77	3.30±0.83	<0.001
HDL mmol/L	1.30±0.31	1.45±0.32	<0.001
UA umol/L	352.1±79.3	269.3±64.7	<0.001
BMI kg/m^2	25.11±3.45	24.40±3.67	<0.001
WC cm	85.85±9.42	78.72±9.90	<0.001
SBP mmHg	134.3±20.7	131.1±22.2	<0.001
DBP mmHg	82.1±12.9	77.8±12.9	<0.001
Diabetes %	16.3%	12.7%	<0.001
Hypertension %	53.4%	44.1%	<0.001

Uric acid: UA; Fasting plasma glucose: FPG; Alanine aminotransferase: ALT; Triglycerides: TG; Total cholesterol: TC; Body mass index: BMI; Waist circumference: WC; Systolic blood pressure: SBP; Diastolic blood pressure: DBP

Table 2 Characteristics of Eastern Chinese population.

	Percentage % (95%CI)				Means±SD		
	Diabetes	Hypertension	Smoking	Drinking	WC	SBP	BMI
Overall	14.1 (13.4, 14.8)	47.8 (46.8, 48.9)	19.2 (18.3, 20.0)	55.8 (54.8, 56.9)	81.57±10.32	132.4±21.7	24.68±3.60
Location							
Rural	15.8 (14.4, 17.2)	58.7 (56.8, 60.6)	22.9 (21.3, 24.5)	56.6 (54.7, 58.5)	83.14±10.38	139.7±23.2	24.71±3.65
Urban	13.4 (12.6, 14.2)	43.3 (42.1, 44.5)	17.6 (16.7, 18.6)	55.5 (54.3, 56.7)	80.90±10.23	129.4±20.3	24.67±3.58
Age groups							
<40	1.6 (0.9, 2.3)	11.1 (9.4, 12.9)	12.9 (11.0, 14.8)	42.0 (39.2, 44.7)	75.22±10.55	116.8±15.0	23.38±3.61
40-60	11.3 (10.3, 12.2)	41.8 (40.3, 43.3)	20.8 (19.6, 22.0)	54.9 (53.4, 56.5)	80.78±9.87	129.5±20.1	24.82±3.35
>=60	21.5 (20.2, 22.9)	67.1 (65.6, 68.7)	19.4 (18.1, 20.7)	61.5 (59.9, 63.1)	84.60±9.59	141.0±21.5	24.96±3.79
Economic status							
low	12.3 (11.3, 13.3)	47.8 (46.3, 49.4)	21.2 (19.9, 22.5)	46.6 (45.1, 48.2)	81.07±10.57	134.2±23.5	24.50±3.55
high	15.6 (14.6, 16.6)	47.8 (46.4, 49.2)	17.6 (16.5, 18.6)	62.9 (61.6, 64.3)	81.96±10.10	131.0±20.1	24.83±3.64
BMI							
<24	9.8 (8.9, 10.7)	35.2 (33.7, 36.7)	16.6 (15.4, 17.7)	52.9 (51.3, 54.5)	74.72±7.85	126.9±21.1	21.67±1.69
24-28	15.2 (14.0, 16.4)	53.0 (51.4, 54.7)	20.6 (19.2, 21.9)	58.3 (56.7, 59.9)	84.57±7.30	135.2±21.2	25.79±1.12
>=28	24.1 (21.8, 26.3)	69.1 (66.7, 71.5)	22.8 (20.6, 25.0)	57.6 (55.0, 60.2)	93.34±8.52	140.5±20.2	30.40±3.09
Glucose status							
normal	-	37.0 (35.6, 38.3)	16.2 (15.1, 17.2)	50.6 (49.3, 52.0)	78.95±9.88	128.0±20.6	24.08±3.44
prediabetes	-	57.6 (55.7, 59.5)	23.4 (21.7, 25.0)	63.2 (61.3, 65.1)	83.90±9.53	136.7±21.6	25.26±3.55
diabetes	-	72.7 (70.3, 75.2)	23.0 (20.6, 25.3)	61.3 (58.7, 64.0)	87.60±9.97	141.9±21.2	26.00±3.78

Body mass index: BMI; Waist circumference: WC; Systolic blood pressure: SBP

Table 3 Biochemical index of Eastern Chinese population.

	Means±SD							
	UA	LDL	TG	HDL	TC	FPG	HbA1c	Creatinine
Overall	302.0±81.5	3.28±0.81	1.68 ±1.48	1.39 ±0.32	5.22 ±1.14	5.58±1.48	5.70±0.99	77.31±14.96
Location								
Rural	294.8±83.0	3.38±0.83	1.69±1.56	1.44±0.31	5.37±1.07	5.63±1.60	5.80±1.03	73.76±14.20
Urban	305.6±80.9	3.23±0.80	1.67±1.43	1.37±0.33	5.16±1.17	5.57±1.42	5.65±0.96	78.87±15.13
Age groups								
<40	294.1±85.7	2.81±0.65	1.35±1.25	1.39±0.30	4.60±0.87	4.98±0.76	5.09±0.57	75.82±14.73
40-60	298.0±82.8	3.29±0.78	1.76±1.71	1.39±0.32	5.24±1.16	5.52±1.46	5.62±0.94	76.26±14.59
>=60	310.1±78.3	3.42±0.83	1.69±1.20	1.38±0.34	5.39±1.13	5.86±1.60	5.98±1.04	79.09±15.47
Economic status								
low	299.8±85.1	3.23±0.82	1.70±1.65	1.45±0.32	5.20±1.05	5.54±1.48	5.62±0.99	76.29±15.23
high	304.4±78.7*	3.31±0.80*	1.66±1.31	1.34±0.32*	5.23±1.21	5.62±1.47*	5.75±0.98*	78.20±14.83*
BMI								
<24	279.5±73.3	3.15±0.80	1.35±1.05	1.48±0.33	5.11±1.09	5.39±1.35	5.53±0.92	75.83±14.26
24-28	313.9±81.7	3.36±0.81	1.85±1.50	1.33±0.30	5.28±1.18	5.64±1.47	5.76±0.99	78.34±15.37
>=28	335.5±85.3	3.44±0.80	2.20±2.13	1.27±0.28	5.39±1.17	6.00±1.74	6.02±1.10	78.95±15.44
Glucose status								
normal	294.9±81.3	3.12±0.76	1.54±1.38	1.41±0.32	5.05±1.10	5.09±0.54	5.16±0.36	76.81±14.77
prediabetes	313.1±81.1	3.51±0.81	1.71±1.17	1.38±0.32	5.49±1.12	5.45±0.72	5.93±0.20	77.95±14.83
diabetes	310.9±81.2	3.42±0.86	2.18±2.14	1.29±0.32	5.38±1.21	7.89±2.63	7.38±1.49	78.22±16.38

Uric acid: UA; Triglycerides: TG; Total cholesterol: TC; Low-density lipoprotein: LDL; High-density lipoprotein: HDL; Glycated hemoglobin: HbA1c; Fasting plasma glucose: FPG

Table 4 Estimated prevalence of HUA in Eastern Chinese population.

	Percentage % (95%CI)		
	Overall	Men	Women
Overall	12.3 (11.6, 12.9)	17.9 (16.7-19.1)	8.5 (7.8-9.3)
Overall*	11.3 (9.9, 12.7)	20.7 (17.7, 23.7)	5.6 (4.3, 6.7)
Location			
Urban	12.9 (12.1, 13.7)	19.1 (17.6-20.7)	8.9 (8.0-9.8)
Rural	10.8 (9.6, 12.0)	15.2 (13.1-17.3)	7.7 (6.4-9.0)
Age groups			
<40	10.8 (9.0, 12.5)	22.8 (19.0, 26.6)	3.3 (2.0, 4.5)
40-60	11.2 (10.3, 12.2)	18.9 (17.0, 20.8)	6.5 (5.5, 7.4)
>=60	13.9 (12.8, 15.0)	15.4 (13.6, 17.2)	12.8 (11.4, 14.2)
Economic status			
low	11.8 (10.9-12.8)	18.3 (16.5-20.1)	7.2 (6.1-8.2)
high	12.6 (11.7-13.5)	17.5 (15.8-19.2)	9.5 (8.5-10.6)
BMI			
<24	6.7 (5.9, 7.5)	10.5 (8.9, 12.2)	4.8 (3.9, 5.6)
24-28	14.1 (13.0, 15.3)	19.9 (18.0, 21.9)	9.4 (8.1, 10.7)
>=28	22.5 (20.3, 24.6)	27.3 (23.9, 30.8)	18.5 (15.7, 21.2)
Glucose status			
normal	10.1 (9.3-10.9)	17.5 (15.8-19.2)	5.7 (4.9-6.5)
prediabetes	15.2 (13.9-16.6)	20.3 (17.9-22.7)	11.6 (10.0-13.2)
diabetes	15.1 (13.1-17.0)	15.0 (12.1-17.8)	15.2 (12.5-17.9)

Body mass index: BMI

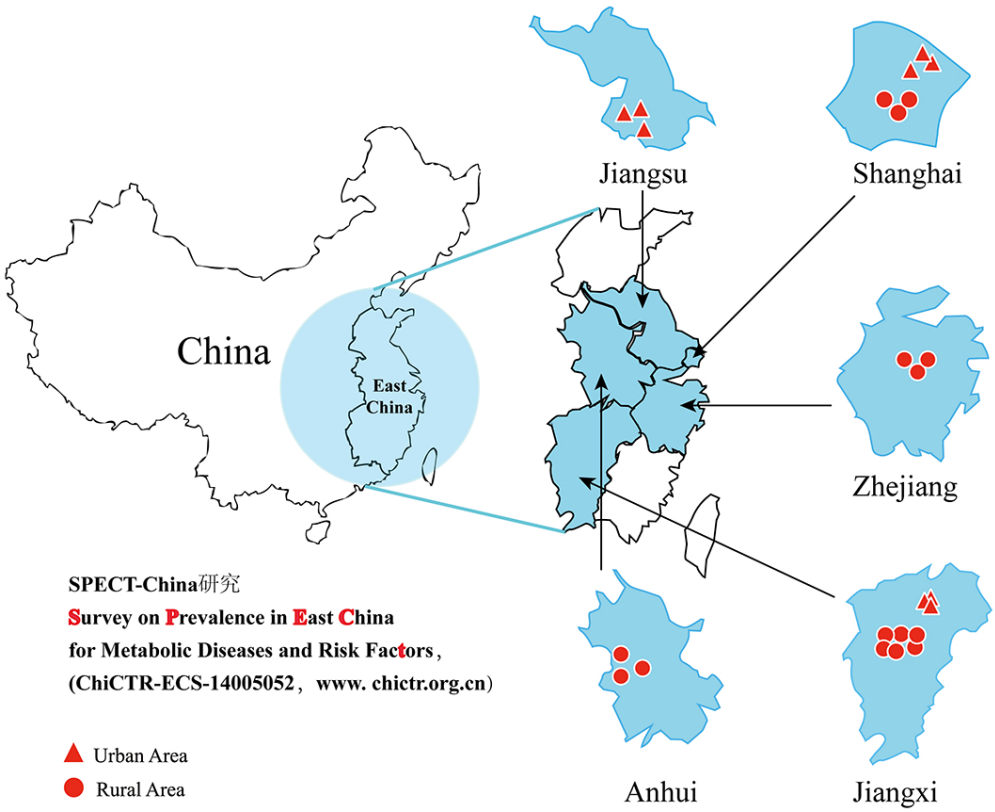
* standardized by proportions of population of 6th national population census data

Table 5 Risk factors for HUA in Eastern Chinese population.

Risk factors	OR	(95%CI)
Female sex	0.510	0.427, 0.609
Age per 10 years	1.041	0.976, 1.112
Urban residency	2.218	1.681, 2.927
≥Junior middle school education	1.042	0.866, 1.253
Lipids		
LDL per 1SD	1.018	0.888, 1.168
HDL per 1SD	0.936	0.850, 1.032
TC per 1SD	1.226	1.050, 1.432
TG per 1SD	1.672	1.491, 1.875
Current smoking	0.942	0.778,1.141
Current drinking	0.913	0.784,1.062
BMI		
Overweight	1.772	1.481, 2.120
Obesity	2.874	2.338, 3.532
Blood pressure		
SBP per 10mmHg	1.055	1.009, 1.103
DBP per 10mmHg	1.012	0.944, 1.085
High economic status	0.688	0.538, 0.879

Data are expressed as unStandardized B (95%CI). The enter procedure was used.

Body mass index: BMI


China
East China
Jiangsu
Shanghai
Zhejiang
Anhui
Jiangxi
SPECT-China研究
Survey on Prevalence in East China
for Metabolic Diseases and Risk Factors,
(ChiCTR-ECS-14005052，www. chictr.org.cn)
Urban Area
Rural Area

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1,2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	Not Applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	7
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Not Applicable
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Not Applicable
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Not Applicable
		Cross-sectional study—Report numbers of outcome events or summary measures	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9,10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other Information			

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence of hyperuricemia in an eastern Chinese population: a cross-sectional study

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Prevalence of hyperuricemia in an eastern Chinese population: a cross-sectional study

Bing Han*, Ningjian Wang, Yi Chen, Qin Li, Chunfang Zhu, Yingchao Chen and Yingli Lu*

Institute and Department of Endocrinology and Metabolism, Shanghai Ninth People's Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China

Correspondance: Dr Yingli Lu, luyingli2008@126.com and Bing Han, hanbing1423@163.com.

Running title: Prevalence of hyperuricemia in China.

ABSTRACT

Objectives: In the past decade, China has been characterized by large-scale urbanization as well as rapid economic growth. The aim of this study was to further investigate the prevalence of hyperuricemia (HUA) in an eastern Chinese population.

Design: Cross-sectional study.

Setting: Survey of Prevalence in East China of Metabolic Diseases and Risk Factors (SPECT-China) study.

Participants: In this study, 12,770 residents from 22 sites in eastern China were recruited. Finally, 9,225 subjects were included.

Main outcome measures: The serum levels of uric acid, fasting plasma glucose (FPG), glycated hemoglobin (HbA1c) and other metabolic parameters were tested. Waist circumference (WC), weight, height and blood pressure were also measured. Questionnaires regarding smoking, drinking, education, etc., were collected from the subjects. HUA was defined as serum UA >420 μmol/L for men and >360 μmol/L for women.

Results: The prevalence of HUA in this eastern Chinese population was 11.3% (9.9, 12.7) overall, 20.7% (17.7, 23.7) in men and 5.6% (4.3, 6.7) in women. The prevalence of HUA in urban subjects was higher than that in rural subjects (12.9 vs. 10.8%, $P<0.01$). The prevalence of HUA was negatively and positively associated with age in men and women, respectively. Residents with high body mass index (BMI) levels had a higher prevalence of HUA. In the logistic regression analysis, male sex, urban residency, total cholesterol (TC), triglyceride (TG), overweight, obesity, systolic blood pressure (SBP) and low economic status were independently correlated with HUA.

Conclusions: The estimated prevalence of HUA in this eastern Chinese population was 11.3% (9.9, 12.7) overall and 20.7% (17.7, 23.7) and 5.6% (4.3, 6.7) in men and women, respectively. HUA has gradually become an important public health issue in China.

Trial registration: ChiCTR-ECS-14005052.

Keywords: Prevalence, hyperuricemia, economic growth, public health, risk factors

Strengths and limitations of this study

- This is the largest published hyperuricemia study in an eastern Chinese population.
- This study covers residents from 22 sites in five provinces.
- This is a regional survey instead of a national study.
- We do not consider the influence of diet.

Abbreviations: HUA, hyperuricemia; FPG, fasting plasma glucose; WC; waist circumference; BMI, body mass index; LDL, low-density lipoprotein; TG, triglyceride; HDL, high-density lipoprotein; TC, total cholesterol; HbA1c, Glycated hemoglobin; SBP, systolic blood pressure; DBP, diastolic blood pressure; NAFLD, Nonalcoholic fatty liver disease; CKD, chronic kidney disease; NGT, Normal glucose tolerance; GDP, gross domestic product; HPLC, high-performance liquid chromatography

Introduction

In humans, uric acid (UA) is the end product of purine metabolism and is mainly excreted via the kidneys. Xanthine oxidoreductase catalyzes two enzymatic reactions, hypoxanthine to xanthine and xanthine to UA. Several conditions can influence the concentration of serum UA, including purine-rich food intake, neoplastic disease, cytotoxic drugs, obesity, hypertension, etc. [1-3].

Uric acid is reported to be associated with oxidative stress and inflammation [1, 4]. In patients with hyperuricemia (HUA), deposition of UA in joints and tissues promotes the occurrence of gout and chronic nephropathy. HUA has also been reported to be associated with insulin resistance, nonalcoholic fatty liver disease (NAFLD) [5, 6], metabolic syndrome, type 2 diabetes, atherosclerosis and coronary heart disease [7-11]. The overall prevalence of HUA in adults in the United States was 21.4% in 2007-2008 [12]. In 2009-2010, Liu H et al showed the adjusted prevalence of HUA was 8.4% in Chinese adults [13]. Recently, Lu X et al conducted a nationwide survey in 31 provinces in China. The prevalence of HUA were 13.7%-18.8% based on different urine iodine concentrations[14]. These studies were national cross-sectional surveys using multistage, stratified sampling. There were also several local or regional investigations. In Henan Rural Cohort Study conducted from 2015 to 2017, the crude and age-standardized prevalence of HUA were 10.24% and 12.60%, respectively[15]. In 2017, Chen Y et al found that the prevalence of HUA was 13.4% in Jidong community of Tangshan City in northern China[16]. In an elderly Chinese population of 7 areas, the overall prevalence of HUA was 13.1% in 2018 [17]. Liu R et al [18] also conducted a meta-analysis including 38 regional studies between 2000 and 2014 to determine the prevalence of HUA in mainland China. The pooled prevalence of HUA was 13.3% (male 19.4% and female 7.9%).

In the past decade, China has been characterized by large-scale urbanization. The percentage of the urban population rose from 18% in 1978 to 56% in 2015 [19]. As serum UA is closely related to economic development and urbanization [15], it is necessary to understand the latest prevalence of HUA in China.

China is characterized by regional and economic diversity. Eastern China has a relatively higher economic status than the rest of the country. In the present study, we performed a cross-sectional survey to investigate the prevalence of HUA and its risk factors in an eastern

Chinese population.

Methods

Study population

Data from the current study are from the Survey of Prevalence in East China of Metabolic Diseases and Risk Factors (SPECT-China), which is a population-based cross-sectional survey of the prevalence of metabolic diseases and risk factors in eastern China [20]. The registration number is ChiCTR-ECS-14005052 (www.chictr.org). 12,770 residents from 22 sites in five provinces (Shanghai, Zhejiang, Jiangsu, Anhui and Jiangxi) were recruited from January 2014 to December 2015 (Supplemental Figure 1). The inclusion and exclusion criteria were described previously [20]. Local residents more than 18 years old and lived in their current area for more than 6 months were included in this study. We excluded subjects with severe communication problems, acute illness, or an unwillingness to participate. We also excluded residents who had no UA data (n=3,535) and chronic kidney disease (CKD) stage 5 (n=10). Finally, 9,225 subjects were included. This study was approved by the ethics committee of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine. Informed consent was obtained from all the participants.

Measurements and definition

HUA was defined as serum UA >420 μmol/L for men and >360 μmol/L for women [21]. Blood pressure and heart rate were measured with a sphygmomanometer (TERUMO-Elemano) three times. Mean value of the three records was used in the analysis. Hypertension was defined as a systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure (DBP) ≥ 90 mmHg or any self-reported history of hypertension. Diabetes was defined as a self-reported history of diabetes or glycated hemoglobin (HbA1c) levels of 6.5% or more. Prediabetes was defined as HbA1c concentrations between 5.7% and 6.4%. Normal glucose tolerance (NGT) was defined as an HbA1c less than 5.7% [22]. Weight, height and waist circumference (WC) were measured by standard procedure. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Overweight and obesity were defined as 24 $kg/m^2 \leq BMI < 28$ kg/m^2 and $BMI \geq 28$ kg/m^2, respectively. Demographic characteristics and lifestyle risk factors were collected by standard questionnaires. Current smoking, drinking and economic status were defined as previously described [23,24].

Assessment of biochemical indexes

After fasting for 8 hours, venous blood samples were drawn from all participants and quickly centrifuged at room temperature. Within 2-4 hours of collection, blood samples were stored at -20ºC and transported by air in dry ice to one central laboratory certified by the College of American Pathologists as previously described [25]. Serum UA was analyzed with a Beckman Coulter AU 680 device with the original kit (Brea, California, USA). The validity and accuracy of UA were 6% and 4%, respectively. Other biochemical indexes were analyzed as described previously [26].

Statistical analysis

We performed statistical analysis by IBM SPSS Version 22 (IBM Corporation, Armonk, New York). Demographic and metabolic characteristics are expressed as the mean ± SD for continuous variables and percentages (95% CI) for categorical variables in the overall population and in subgroups of location, age, economic status, BMI and glucose status. Logistic analysis was used to investigate the association of demographic, lifestyle, and metabolic factors with the odds of HUA. According to the 6th national population census data, the proportions of the population in different age groups (<40, 40-60, ≥60) are 57.39%, 29.29%, and 13.31% (total); 58.10%, 29.13%, and 12.76% (male); and 56.61%, 29.46%, and 13.91% (female), respectively [27]. Thus, we adjusted the prevalence of HUA by these proportions. All analyses were two-sided. $P<0.05$ was considered significant.

Patient and public involvement

Patients and the public were not involved in the development of research questions, design of the study, recruitment and conduct of the study or dissemination of the study results.

Results

Characteristics of this eastern Chinese population

In our study, we analyzed UA in 9,225 Chinese adults, including 3,682 males (age, 55.57±13.23 y) and 5,543 females (age 54.30±12.82 y). The mean levels of serum UA were 352.12±79.30 nmol/L and 269.29±64.68 nmol/L in males and females, respectively. There were significant sex differences in blood glucose, blood lipids, UA, BMI, WC and blood pressure. The prevalence of diabetes and hypertension also showed a significant difference (Table 1).

Metabolic risk factors of this eastern Chinese population

The prevalence of diabetes and hypertension, WC, SBP and BMI increased with age. As BMI and glucose levels rose, the prevalence of hypertension, WC, SBP, BMI, triglyceride (TG), FPG, and HbA1c increased. Moreover, people living in rural areas had a higher prevalence of diabetes, WC, SBP, low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol (TC) and HbA1c. People with a high economic status had a higher prevalence of diabetes, WC, UA, BMI, LDL, FPG, HbA1c and Cr (Tables 2, 3).

Estimated prevalence of HUA in this eastern Chinese population

The prevalence of HUA was 12.3% (11.6, 12.9), with 17.9% (16.7, 19.1) and 8.5% (7.8, 9.3) in males and females, respectively. The prevalence of HUA in urban areas was higher than that in rural areas (12.9% vs. 10.8%). The prevalence of HUA in developed areas was slightly higher than that in underdeveloped areas (12.6% vs. 11.8%). As BMI increased, the prevalence of HUA increased in both men and women. The prevalence of HUA in normal, prediabetic and diabetic women were 5.7% (4.9, 6.5), 11.6% (10.0, 13.2) and 15.2% (12.5, 17.9) respectively (Table 4). So there was an increased trend of prevalence of HUA in women with different glucose status. However, this trend was not obvious in men. After adjusting for the proportions of the population in different age groups, the prevalence of HUA was 11.3% (9.9, 12.7), with 20.7% (17.7, 23.7) and 5.6% (4.3, 6.7) in males and females, respectively (Table 4). When HUA was defined as serum UA of more than 420 μmol/L in both men and women, the prevalence of HUA was 8.4% (7.8, 9.0) in total and 2.1% (1.7, 2.5) in females.

After adjusting for the proportions of the population in different age groups, the prevalence of HUA was 8.8% (7.5, 10.1) in total and 1.4% (0.7, 2.0) in females (Supplemental Table 1).

Logistic regression analysis of HUA

Male sex, urban residency, increased TC or TG, overweight, obesity, elevated SBP and low economic status were all risk factors for HUA in this eastern Chinese population (Table 5). However, increased age, higher educational status, increased LDL or HDL, current smoking or drinking and elevated DBP were not associated with the risk of HUA. When HUA was defined as serum UA of more than 420 μmol/L in both men and women, the association was similar to the above results (Supplemental Table 2).

Discussion

In this eastern Chinese population, the prevalence of HUA was 11.3%, which was similar to the pooled prevalence reported in a systematic review performed in China (13.3%) [18]. However, this prevalence was more than that in the national HUA survey, which reported that the prevalence of HUA was 8.4% in 2009-2010 [13]. These two studies investigated different populations. Recently, a national study was performed on the relationship between hyperuricemia and iodine intake. The prevalence of hyperuricemia was 17.8%, 18.8%, 16.0% and 13.7% in the urinary iodine concentrations (UICs) <100, 100-199, 200-299, and ≥300ug/L groups [14]. Our result was between these national surveys, which was performed in 2014-2015. As a regional study, the prevalence of our result was similar to other regional investigations in China[15-18]. However, our prevalence was relatively lower than that in Qingdao, Shandong Province, which is close to the sea and where residents consume high amounts of seafood and beer [28]. Moreover, the prevalence of HUA in our population was lower than those in the United States and Japan [12, 29], which might be attributed to economic status.

The prevalence of HUA in young men (<40 years) was seven times greater than that in young women. However, as age increased, the prevalence of HUA gradually decreased in men and increased in women, which was coincident with values previously reported [30]. In residents more than 60 years of age, men and women had a similar prevalence of HUA. We deduced that the diet of young men contains more purine than that of old men. The young men also had an active metabolism. The prevalence of HUA was dramatically increased in women older than 60 years, which might be caused by reduced estrogen levels.

Risk factors for HUA were also evaluated in our study. We found that male sex, urban residency, hypertriglyceridemia, hypercholesterolemia, overweight, obesity, high SBP and low economic status were risk factors for HUA. In previous studies, hypertriglyceridemia was thought to be the strongest risk factor for HUA [30, 31]. However, the OR for HUA was 1.7 times with 1 SD elevation of triglyceridemia. In addition, obesity was the strongest risk factor (OR=2.874) in our study. China has the largest obese population in the world [32]. In this case, the prevalence of HUA will increase with the rising trend of obesity. Therefore, we should pay more attention to prevent its consequences.

HUA is closely related to lifestyle and dietary habits. In previous studies, the prevalence of HUA in urban areas was much greater than that in rural areas [13, 30]. In our study, the prevalence of HUA in urban areas was mildly elevated (12.9% vs. 10.8%), and urbanization was a risk factor for HUA. Eastern China is considered the developed area in the whole country. Therefore, the difference between urban and rural areas was not obvious as in other places. Moreover, people with high economic status consumed more healthy food that contained low purine ingredients. This could partly explain why low economic status became a risk factor for HUA. In accordance with a previous study, smoking was not associated with HUA [13]. However, according to a previous study, alcohol intake influences serum UA, which is different from the results of our study. This difference might have been caused by our definition of current drinking (current drinking was defined as drinking in the past 1 month), which mixed nonhabitual drinkers and habitual drinkers together.

As age increased, UA together with components of metabolic syndrome (FPG, SBP, WC) also increased, which indicated that there might be a close relationship between metabolic syndrome and HUA. Other studies have also found that HUA is associated with metabolic syndrome [33, 34]. An epidemiologic study showed that HUA is positively correlated with fasting serum insulin [35]. Krishnan et al reported that people with HUA have 1.36 times the risk of developing insulin resistance in a 15-year follow-up study [36]. Thus, research has indicated that insulin resistance plays an important role in the relationship between metabolic syndrome and HUA [37].

There were several limitations in our study. First, this was not a national study but a local survey. Second, we did not consider the influence of diet. Blood was drawn after fasting for eight hours. However, the diet ingested near the blood drawing time was unknown. In addition, this was a cross-sectional study. Therefore, we could not identify a causal relationship between HUA and its risk factors.

In this study, we estimated the prevalence of HUA in an eastern Chinese population. To prevent the prevalence of HUA, more attention should be paid to life status (such as economic status and residence) and metabolic indexes (TC, TG, BMI, and SBP).

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Contributors

YL and BH designed and supervised this investigation. BH performed this investigation. YC, CFZ and YCC contributed to the data collection. NJW and QL provided technical or material support. All authors read and approved the final manuscript.

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Competing interests

The authors have declared that no competing interests exist.

Patient consent for publication

Not required

Ethical approval

The study protocol was approved by the Institutional Review Board of the Shanghai Ninth People's Hospital affiliated with Shanghai Jiaotong University School of Medicine.

Provenance and peer review

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Data availability statement

Data are available upon request to corresponding author.

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Figure legend

Supplemental Figure 1 Position of the 5 provinces and 22 sites in China.

Residents from 22 sites in Shanghai, Zhejiang, Jiangsu, Anhui and Jiangxi provinces were enrolled in SPECT-China study.

Table 1 Baseline characteristics between different groups.

Variables	Men (n=3682)	Women (n=5543)	P value
Age y	55.57±13.23	54.30±12.82	<0.001
FPG mmol/L	5.72±1.63	5.50±1.36	<0.001
HbA1c %	5.78±1.08	5.64±0.92	<0.001
TG mmol/L	1.88±1.79	1.55±1.20	<0.001
TC mmol/L	5.14±1.13	5.27±1.15	<0.001
LDL mmol/L	3.23±0.77	3.30±0.83	<0.001
HDL mmol/L	1.30±0.31	1.45±0.32	<0.001
UA umol/L	352.1±79.3	269.3±64.7	<0.001
BMI kg/m^2	25.11±3.45	24.40±3.67	<0.001
WC cm	85.85±9.42	78.72±9.90	<0.001
SBP mmHg	134.3±20.7	131.1±22.2	<0.001
DBP mmHg	82.1±12.9	77.8±12.9	<0.001
Diabetes %	16.3%	12.7%	<0.001
Hypertension %	53.4%	44.1%	<0.001

Uric acid: UA; Fasting plasma glucose: FPG; Alanine aminotransferase: ALT; Triglycerides: TG; Total cholesterol: TC; Body mass index: BMI; Waist circumference: WC; Systolic blood pressure: SBP; Diastolic blood pressure: DBP

Table 2 Characteristics of Eastern Chinese population.

	Percentage % (95%CI)				Means±SD		
	Diabetes	Hypertension	Smoking	Drinking	WC	SBP	BMI
Overall	14.1 (13.4, 14.8)	47.8 (46.8, 48.9)	19.2 (18.3, 20.0)	55.8 (54.8, 56.9)	81.57±10.32	132.4±21.7	24.68±3.60
Location							
Rural	15.8 (14.4, 17.2)	58.7 (56.8, 60.6)	22.9 (21.3, 24.5)	56.6 (54.7, 58.5)	83.14±10.38	139.7±23.2	24.71±3.65
Urban	13.4 (12.6, 14.2)	43.3 (42.1, 44.5)	17.6 (16.7, 18.6)	55.5 (54.3, 56.7)	80.90±10.23	129.4±20.3	24.67±3.58
Age groups							
<40	1.6 (0.9, 2.3)	11.1 (9.4, 12.9)	12.9 (11.0, 14.8)	42.0 (39.2, 44.7)	75.22±10.55	116.8±15.0	23.38±3.61
40-60	11.3 (10.3, 12.2)	41.8 (40.3, 43.3)	20.8 (19.6, 22.0)	54.9 (53.4, 56.5)	80.78±9.87	129.5±20.1	24.82±3.35
>=60	21.5 (20.2, 22.9)	67.1 (65.6, 68.7)	19.4 (18.1, 20.7)	61.5 (59.9, 63.1)	84.60±9.59	141.0±21.5	24.96±3.79
Economic status							
low	12.3 (11.3, 13.3)	47.8 (46.3, 49.4)	21.2 (19.9, 22.5)	46.6 (45.1, 48.2)	81.07±10.57	134.2±23.5	24.50±3.55
high	15.6 (14.6, 16.6)	47.8 (46.4, 49.2)	17.6 (16.5, 18.6)	62.9 (61.6, 64.3)	81.96±10.10	131.0±20.1	24.83±3.64
BMI							
<24	9.8 (8.9, 10.7)	35.2 (33.7, 36.7)	16.6 (15.4, 17.7)	52.9 (51.3, 54.5)	74.72±7.85	126.9±21.1	21.67±1.69
24-28	15.2 (14.0, 16.4)	53.0 (51.4, 54.7)	20.6 (19.2, 21.9)	58.3 (56.7, 59.9)	84.57±7.30	135.2±21.2	25.79±1.12
>=28	24.1 (21.8, 26.3)	69.1 (66.7, 71.5)	22.8 (20.6, 25.0)	57.6 (55.0, 60.2)	93.34±8.52	140.5±20.2	30.40±3.09
Glucose status							
normal	-	37.0 (35.6, 38.3)	16.2 (15.1, 17.2)	50.6 (49.3, 52.0)	78.95±9.88	128.0±20.6	24.08±3.44
prediabetes	-	57.6 (55.7, 59.5)	23.4 (21.7, 25.0)	63.2 (61.3, 65.1)	83.90±9.53	136.7±21.6	25.26±3.55
diabetes	-	72.7 (70.3, 75.2)	23.0 (20.6, 25.3)	61.3 (58.7, 64.0)	87.60±9.97	141.9±21.2	26.00±3.78

Body mass index: BMI; Waist circumference: WC; Systolic blood pressure: SBP

Table 3 Biochemical index of Eastern Chinese population.

	Means±SD							
	UA	LDL	TG	HDL	TC	FPG	HbA1c	Creatinine
Overall	302.0±81.5	3.28±0.81	1.68 ±1.48	1.39 ±0.32	5.22 ±1.14	5.58±1.48	5.70±0.99	77.31±14.96
Location								
Rural	294.8±83.0	3.38±0.83	1.69±1.56	1.44±0.31	5.37±1.07	5.63±1.60	5.80±1.03	73.76±14.20
Urban	305.6±80.9	3.23±0.80	1.67±1.43	1.37±0.33	5.16±1.17	5.57±1.42	5.65±0.96	78.87±15.13
Age groups								
<40	294.1±85.7	2.81±0.65	1.35±1.25	1.39±0.30	4.60±0.87	4.98±0.76	5.09±0.57	75.82±14.73
40-60	298.0±82.8	3.29±0.78	1.76±1.71	1.39±0.32	5.24±1.16	5.52±1.46	5.62±0.94	76.26±14.59
>=60	310.1±78.3	3.42±0.83	1.69±1.20	1.38±0.34	5.39±1.13	5.86±1.60	5.98±1.04	79.09±15.47
Economic status								
low	299.8±85.1	3.23±0.82	1.70±1.65	1.45±0.32	5.20±1.05	5.54±1.48	5.62±0.99	76.29±15.23
high	304.4±78.7*	3.31±0.80*	1.66±1.31	1.34±0.32*	5.23±1.21	5.62±1.47*	5.75±0.98*	78.20±14.83*
BMI								
<24	279.5±73.3	3.15±0.80	1.35±1.05	1.48±0.33	5.11±1.09	5.39±1.35	5.53±0.92	75.83±14.26
24-28	313.9±81.7	3.36±0.81	1.85±1.50	1.33±0.30	5.28±1.18	5.64±1.47	5.76±0.99	78.34±15.37
>=28	335.5±85.3	3.44±0.80	2.20±2.13	1.27±0.28	5.39±1.17	6.00±1.74	6.02±1.10	78.95±15.44
Glucose status								
normal	294.9±81.3	3.12±0.76	1.54±1.38	1.41±0.32	5.05±1.10	5.09±0.54	5.16±0.36	76.81±14.77
prediabetes	313.1±81.1	3.51±0.81	1.71±1.17	1.38±0.32	5.49±1.12	5.45±0.72	5.93±0.20	77.95±14.83
diabetes	310.9±81.2	3.42±0.86	2.18±2.14	1.29±0.32	5.38±1.21	7.89±2.63	7.38±1.49	78.22±16.38

Uric acid: UA; Triglycerides: TG; Total cholesterol: TC; Low-density lipoprotein: LDL; High-density lipoprotein: HDL; Glycated hemoglobin: HbA1c; Fasting plasma glucose: FPG

Table 4 Estimated prevalence of HUA in Eastern Chinese population.

	Percentage % (95%CI)		
	Overall	Men	Women
Overall	12.3 (11.6, 12.9)	17.9 (16.7-19.1)	8.5 (7.8-9.3)
Overall*	11.3 (9.9, 12.7)	20.7 (17.7, 23.7)	5.6 (4.3, 6.7)
Location			
Urban	12.9 (12.1, 13.7)	19.1 (17.6-20.7)	8.9 (8.0-9.8)
Rural	10.8 (9.6, 12.0)	15.2 (13.1-17.3)	7.7 (6.4-9.0)
Age groups			
<40	10.8 (9.0, 12.5)	22.8 (19.0, 26.6)	3.3 (2.0, 4.5)
40-60	11.2 (10.3, 12.2)	18.9 (17.0, 20.8)	6.5 (5.5, 7.4)
>=60	13.9 (12.8, 15.0)	15.4 (13.6, 17.2)	12.8 (11.4, 14.2)
Economic status			
low	11.8 (10.9-12.8)	18.3 (16.5-20.1)	7.2 (6.1-8.2)
high	12.6 (11.7-13.5)	17.5 (15.8-19.2)	9.5 (8.5-10.6)
BMI			
<24	6.7 (5.9, 7.5)	10.5 (8.9, 12.2)	4.8 (3.9, 5.6)
24-28	14.1 (13.0, 15.3)	19.9 (18.0, 21.9)	9.4 (8.1, 10.7)
>=28	22.5 (20.3, 24.6)	27.3 (23.9, 30.8)	18.5 (15.7, 21.2)
Glucose status			
normal	10.1 (9.3-10.9)	17.5 (15.8-19.2)	5.7 (4.9-6.5)
prediabetes	15.2 (13.9-16.6)	20.3 (17.9-22.7)	11.6 (10.0-13.2)
diabetes	15.1 (13.1-17.0)	15.0 (12.1-17.8)	15.2 (12.5-17.9)

Body mass index: BMI

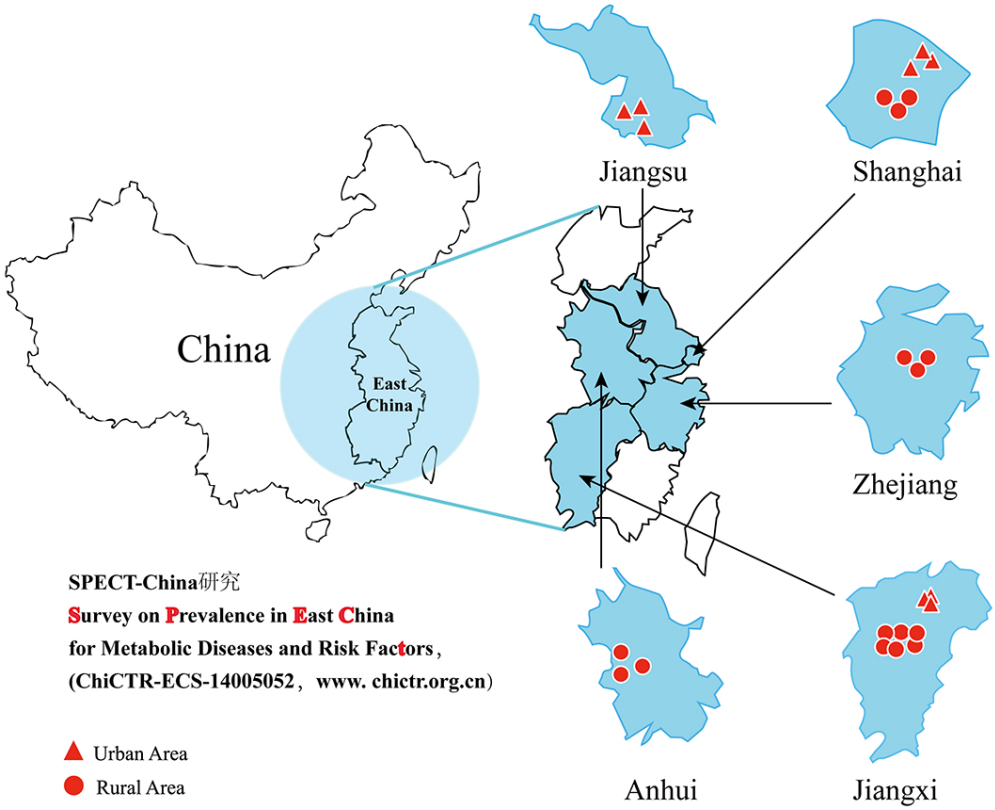
* standardized by proportions of population of 6th national population census data

Table 5 Risk factors for HUA in Eastern Chinese population.

Risk factors	OR	(95%CI)
Female sex	0.510	0.427, 0.609
Age per 10 years	1.041	0.976, 1.112
Urban residency	2.218	1.681, 2.927
≥Junior middle school education	1.042	0.866, 1.253
Lipids		
LDL per 1SD	1.018	0.888, 1.168
HDL per 1SD	0.936	0.850, 1.032
TC per 1SD	1.226	1.050, 1.432
TG per 1SD	1.672	1.491, 1.875
Current smoking	0.942	0.778,1.141
Current drinking	0.913	0.784,1.062
BMI		
Overweight	1.772	1.481, 2.120
Obesity	2.874	2.338, 3.532
Blood pressure		
SBP per 10mmHg	1.055	1.009, 1.103
DBP per 10mmHg	1.012	0.944, 1.085
High economic status	0.688	0.538, 0.879

Data are expressed as unStandardized B (95%CI). The enter procedure was used.

Body mass index: BMI


China
East China
Jiangsu
Shanghai
Zhejiang
Anhui
Jiangxi
SPECT-China研究
Survey on Prevalence in East China
for Metabolic Diseases and Risk Factors,
(ChiCTR-ECS-14005052，www. chictr.org.cn)
Urban Area
Rural Area

Supplemental Table 1 Estimated prevalence of HUA (UA>420μmol/L) in Eastern Chinese population.

	Percentage % (95%CI)	
	Overall	Women
Overall	8.4 (7.8, 9.0)	2.1 (1.7, 2.5)
Overall*	8.8 (7.5, 10.1)	1.4 (0.7, 2.0)
Location		
Urban	8.8 (8.1, 9.5)	2.1 (1.7, 2.6)
Rural	7.5 (6.5, 8.5)	1.9 (1.3, 2.6)
Age groups		
<40	9.3 (7.7, 10.9)	0.9 (0.2, 1.6)
40-60	8.0 (7.2, 8.8)	1.3 (0.8, 1.7)
>=60	8.5 (7.6, 9.4)	3.5 (2.7, 4.2)
Economic status		
low	8.6 (7.7, 9.5)	1.6 (1.1, 2.0)
high	8.2 (7.5, 9.0)	2.5 (1.9, 3.0)
BMI		
<24	4.2 (3.6, 4.8)	0.9 (0.6, 1.3)
24-28	10.1 (9.1, 11.1)	2.1 (1.4, 2.7)
>=28	15.7 (13.8, 17.6)	6.0 (4.4, 7.7)
Glucose status		
normal	7.3 (6.6, 8.0)	1.1 (0.8, 1.5)
prediabetes	10.3 (9.1, 11.4)	3.1 (2.2, 3.9)
diabetes	9.4 (7.8, 10.9)	4.6 (3.0, 6.1)

Body mass index: BMI

* standardized by proportions of population of 6th national population census data

Supplemental table 2 Risk factors for HUA (UA>420μmol/L) in Eastern Chinese population.

Risk factors	OR	(95%CI)
Female sex	0.110	0.086, 0.142
Age per 10 years	0.937	0.867, 1.013
Urban residency	2.292	1.654, 3.176
≥Junior middle school education	1.037	0.835, 1.288
Lipids		
LDL per 1SD	1.014	0.861, 1.193
HDL per 1SD	0.984	0.873, 1.109
TC per 1SD	1.209	1.004, 1.456
TG per 1SD	1.724	1.504, 1.978
Current smoking	0.921	0.755, 1.123
Current drinking	1.008	0.841, 1.209
BMI		
Overweight	1.812	1.448, 2.268
Obesity	2.835	2.191, 3.668
Blood pressure		
SBP per 10mmHg	1.082	1.023, 1.145
DBP per 10mmHg	1.017	0.932, 1.109
High economic status	0.670	0.504, 0.890

Data are expressed as unStandardized B (95%CI). The enter procedure was used.

Body mass index: BMI

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1,2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	Not Applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8

Section/Topic	Item No	Recommendation	Reported on Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	7
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Not Applicable
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Not Applicable
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Not Applicable
		Cross-sectional study—Report numbers of outcome events or summary measures	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10,11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other Information			

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

**Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.*

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.